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Environment and chronic disease in rural areas of Heilongjiang, China (ECDRAHC)

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ABSTRACT

Purpose Environmental factors such as long-term exposure to cold can increase the risk of chronic diseases. However, few studies have focused on the impact of environmental factors and lifestyle changes on chronic diseases. To fully explore the association between exposure to environmental factors and the prevalent risk of various chronic diseases, we conducted a large cohort study (Environment and Chronic Disease in Rural Areas of Heilongjiang, China (ECDRAHC)). The ECDRAHC collected detailed questionnaire data covering 10 sections, physical measurements and blood and urine samples. In this study, we describe the design and implementation of the cohort study and present the findings for the first 10 000 participants.

Participants The ECDRAHC study was carried out in rural areas where the annual average temperature is 2.9°C, and aimed to recruit 40 000 participants who are long-term residents aged 35–74 years. The participants will be followed up every 5 years. Currently, ECDRAHC has reached 26.7% (n=10 694) of the targeted population.

Findings to date A total of 10 694 adults aged 35–74 years were recruited, including 61.7% women. The prevalence of current smokers was 46.8% in men and 35.4% in women. The mean blood pressure was 140.2/89.9 mm Hg and 135.7/85.0 mm Hg in men and women, respectively. The mean body mass index was 24.74 kg/m^2 in men and 24.65 kg/m^2 in women, with >7.3% being obese (>30 kg/m^2). The main non-communicable diseases found in phase 1 were hypertension, diabetes, hypertriglyceridaemia and metabolic syndrome, with a higher prevalence of 51.0%, 21.6%, 46.8% and 42.6%, respectively.

Future plans We plan to complete the follow-up for the first phase of the ECDRAHC in 2024. The second and third phase of the cohort will be carried out steadily, as planned. This cohort will be used to investigate the relationship between environmental factors, lifestyle, and genetic and common chronic diseases.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The cohort study was designed to be conducted in rural areas in Northeast China to validate the interaction between environmental factors and chronic diseases.
⇒ The baseline survey collected detailed and comprehensive information. For instance, in addition to demographics, socioeconomics, lifestyle and health-related histories, we collected biological specimens and performed medical examinations and clinical laboratory tests for every participant.
⇒ The study was conducted in rural areas, and the loss of middle-aged labourers may have affected the age distribution and sex ratio of the study.
⇒ We relied on self-reported data for some variables, such as lifestyle factors and somatosensory temperature, which may incur recall bias.

INTRODUCTION

The interaction between the environment and genes affects the risk of human diseases.[1] In recent years, there has been extensive literature suggesting an increased risk of the incidence and mortality of several chronic diseases in association with long-term exposure to harsh environments, such as cold exposure[2–4] and air pollution.[5–7] Chronic diseases, including cardiovascular and cerebrovascular diseases, cancer, respiratory disease and diabetes, are the leading causes of death globally and mainly occur in middle and old age (35–74).[8] The WHO data suggest that chronic diseases account for 60% of the deaths worldwide, and approximately 80% of these deaths occur in low-income and middle-income countries.[9] Moreover, China is one of the countries with the most serious chronic diseases, especially Northeast China.[10]

The prevalence of chronic diseases in Heilongjiang province, where the winter temperature usually drops below −14°C, is much lower than the national average. Heilongjiang province is located in the far northeast of China and is characterised by long and cold winters. In urban areas, nearly

all households have proper central heating from October to March, keeping the minimum indoor temperature over 18°C. However, in rural areas, individuals arrange heating. Due to poverty, farmers do not like to spend excessive money on heating. Therefore, they may experience long-term cold exposure indoors and outdoors. Some researchers have reported that outdoor temperature can affect blood pressure in participants with cardiocerebrovascular disease.[11–14] However, most studies have concentrated on urban areas, and the results may not directly reflect the relationship between cold exposure and human health. To keep the indoors warm, some rural people use self-made coal-fired stoves or heated brick beds during winter. Firewood and coal used as fuels can cause indoor air pollution, which is easily overlooked. Some studies have pointed out that indoor air pollution is closely related to higher risks of cardiovascular[15] and respiratory disease[16] and all-cause mortality, especially in rural areas.[7] Residents of Northeast China prefer high-salt diets. Moreover, due to the lack of fresh vegetables in winter, rural residents often marinate vegetables with salt and soy sauce to prolong their storage. Salty food is highly associated with cardiovascular diseases. Therefore, the health impact of environmental factors and lifestyle changes in Heilongjiang province, mainly long-term, low-temperature exposure, should be studied.

The Environment and Chronic Disease in Rural Areas of Heilongjiang, China (ECDRAHC) plans to conduct a cohort study in three counties in Heilongjiang province. In 2018, the first phase of the cohort study (ECDRAHC) was launched in Mingshui county, a county of national-level poverty in Heilongjiang province. Baseline and follow-up surveys were conducted for data collection of cohort endpoint events, including the incidence and outcome of common chronic diseases and death. Simultaneously, a biological blood and urine sample bank was established to analyse the relationship between cold, air pollution, lifestyle, and other environmental and genetic factors and the occurrence and development of chronic diseases. This is the first cohort with over 10 000 participants designed specifically in rural areas of Northeast China, which has been defined as a national poverty county for more than 30 years. The aim of this cohort study was to explore the pathogenic factors, pathogenesis, epidemic rules and trends of chronic diseases, and to build a health risk assessment and disease risk prediction model that can be used to formulate effective prevention and control measures for chronic diseases. In this study, we report the detailed survey methods and the main baseline characteristics of the participants.

COHORT DESCRIPTION

Participant demographics and sample collection

The first phase of the study was conducted in the rural area of Mingshui county, which is a typical poor agricultural county in Northeast China. The county is located at high latitudes, with a cold winter lasting as long as 182 days. The annual average temperature is 2.9°C, and the county jurisdiction is over 12 townships, with a population of approximately 340 000. Due to the undeveloped and backward economy, which leads to a lack of health consciousness and is affected by diet, living habits and other factors, the prevalence of various kinds of chronic diseases remains high.

The ECDRAHC covers nine regions in Mingshui county. Rural residents were eligible to participate in the study if they (1) were between 35 and 74 years old, (2) registered residence in the province and lived locally for more than 1 year and (3) voluntarily participated in and accepted the questionnaire and agreed to complete the follow-up of the permanent population. The exclusion criteria for participant recruitment were obstacles to communication and major physical illness. A unique 6-digit code was assigned to each participant. After enrolment, the participants went to the clinical laboratories for blood and urine collection. A face-to-face questionnaire survey was conducted by uniformly trained investigators to collect data on general demographic characteristics, socioeconomic factors, health status and social support. The questionnaire data were reviewed scrupulously. If there were any omissions or logical errors, the investigator immediately supplemented and provided feedback.

The baseline survey of the ECDRAHC cohort was conducted between November 2018 and September 2019. Participants were required to provide written informed consent to allow the input of their clinical, epidemiological and biological data into the cohort database for scientific purposes. Informed consent includes the use of data for research purposes and permission to collect patient biosamples for analysis. This study was conducted in nine townships in the county. Considering the cold weather and slippery road in winter and the older participants, we decentralised the evaluation centre to each township. At each survey site, the team consisted of 15 full-time staff members with medical qualifications and fieldwork experience. After extensive publicity campaigns, local health workers informed potential participants door to door to voluntarily participate in the project. Participants were requested to bring their ID cards to the evaluation centre and come without having food and water for at least 8 hour. Individuals aged <35 or >74 years or who did not meet the inclusion criteria were also excluded from the cohort. After informed consent was obtained, a questionnaire survey, physical examination and biological sample collection were conducted. The entire visit took nearly 60 min to collect information of one participant.

Baseline survey

A baseline survey was conducted with all study participants. For baseline survey, data were collected from the questionnaires, physical measurements and laboratory testing of blood and urine samples. The questionnaire included the following sections: (1) demographic characteristics (sex, age, nationality, etc); (2) socioeconomic factors (education level, marital status, family

Table 1 Summary of measurements at the baseline survey in the Environment and Chronic Disease in Rural Areas of Heilongjiang, China Cohort study

Measurements	Variables
Electronic questionnaire	
Demographics and socioeconomic status	National ID number, home address, date of birth, sex, marital status, ethnic group, education, occupation, type of medical insurance, contact information, household registration status, annual income, poor household
Health status	Smoking status, smoking cessation, passive smoking exposure, frequency of drinking, types of drink, amount of alcohol consumption, family and personal disease history, medication history, physical activity, sleep habits
Reproductive history (for women)	Age of menarche, menopause status, experience of pregnancy, history of breast feeding, history of contraceptive pills uses, history of hysterectomy and ovary/breast surgery, history of intrauterine contraceptive device
Diet	Cooking oil and salt consumption, Food Frequency Questionnaire, nutritional supplements intake, history of severe food shortage
Indoor temperature and air pollution in winter	Temperature in work place, somatosensory temperature, fuel used during cooking and heating
Psychological assessment	Self-Rating Depression Scale and Self-Rating Anxiety Scale
Medical examination	
Physical examination	Height, weight, waist circumferences, fasting blood pressure (measured three times, OMRON HEM-8711), fasting heart rate (measured three times, OMRON HEM-8711)
Lung function	Vital capacity and forced vital capacity (OMRON HI-101)
Glucose spot detection	Blood glucose detection
Body composition analyse	Body composition analyser
Urine	Specific gravity, urobilinogen, urinary bilirubin, urinary ketone body, urine glucose, urinary protein, pH, urine nitrite
ECG	12-Lead ECG (NIHON KOHDEN ECG-2350)
Clinical laboratory test	
Lipid levels	Triglycerides, cholesterol, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol
Hepatic function	Total protein, albumin, globulin, alanine transaminase, aspartate amino transferase, gamma-glutamyl transpeptidase, alkaline phosphatase, total bilirubin
Kidney function	Creatinine, urea, uric acid
Blood glucose	Blood glucose
Urine	N-acetyl-β-D-glucosaminidase, microalbumin
Ion	Iron, magnesium, zinc, calcium, phosphorus, copper
Cardiac function	Creatine kinase isomer-MB, creatine kinase, lactate dehydrogenase

composition, income, occupation, etc); (3) health status (smoking, drinking status, disease history, medication history, etc); (4) female health assessment (for women only, history of pregnancy and gynaecological diseases, etc); (5) dietary habits; (6) indoor temperature in winter; and (7) psychological assessment. The questionnaire design in ECDRAHC is based on international standards and gathers information on environmental and genetic risk factors for chronic diseases. The details of the questionnaire administered to the selected participants are presented in table 1. Data on annual income status were also collected. In the survey of dietary habits, we focused on the intake of salt and oil, fresh vegetables and fruits and pickled foods. The indoor temperature is represented by the somatosensory temperature. Cognitive function was evaluated using the Self-Rating Depression Scale[17] and Self-Rating Anxiety Scale.[18] To ensure the accuracy of the survey, we prepared a separate room for the participants who experienced emotional fluctuations during the questionnaire. Medical measurements (shown in table 1), including height, weight, hip and waist circumferences (WCs), lung function, blood pressure and ECG, were also taken at baseline by well-trained examiners with standard instruments and protocols. Body composition analysers were used to measure the bioelectrical impedance of the human body to calculate the ratio of body fat, water and other tissue components. Blood spot for glucose detection, urine and 10 mL blood samples were collected from each participant after overnight fasting (>8 hour). The blood samples were centrifuged, and the whole blood, serum and plasma were equally divided into four cryopreservation tubes. After freezing for 2 weeks at

–80°C, samples were couriered to the biobank in Harbin with dry ice and stored separately in four refrigerators at –80°C. Urine samples were divided into four tubes and transported to Harbin for further analysis. Various biological indicators were analysed (table 1). All laboratory analyses were conducted by trained professionals at the Harbin Medical University. Quality control was applied before every detection per day. Freeze thaw occurred only once between collection and detection. Quality control was performed to eliminate the differences caused by examiners in different towns. Participants were randomly selected and the questionnaire was reviewed to ensure the reliability of the original data. After the baseline data investigation, a logical and reasonable range of data was checked throughout the questionnaire, and a supplementary investigation was conducted for unreasonable content.

Follow-up

The study is designed as a prospective cohort study with follow-up every 2 years. The first follow-up has already been completed. The follow-up contents were as follows: (1) Endpoint events: cardiovascular and cerebrovascular diseases, cancer, diabetes, chronic obstructive pulmonary disease and all causes of death. The diagnosis of diseases is based on international standards, and the classification is performed according to International Classification of Diseases 11th Revision. (2) Migration and loss of visits from the participants. The following steps were used for follow-up: (1) Follow-up methods: follow-up was carried out by the end-point event tracking system; after 1 year of baseline investigation, an efficient end-point event tracking system was established based on the data of medical insurance and public security departments, and followed up with active and passive monitoring. (2) Follow-up survey: besides every 2-year follow-up survey, all members were investigated again in the fifth year after the establishment of the cohort. The survey content was consistent with that of the baseline survey, including a questionnaire survey, physical examination, blood and urine sample collection and laboratory tests. Meanwhile, end-point events, migration and loss of visits from participants were investigated, and the data were checked. (3) Event review: a terminal event review committee, composed of clinical experts, was specially established to evaluate the end-point events monitored by follow-up according to the established diagnostic criteria and standard procedures to ensure the accuracy of the outcome events.

Patient and public involvement

The patients or public were not involved in the design, conduct, reporting or dissemination plans of our research.

FINDINGS TO DATE

The main characteristics of the first 10 000 study participants at baseline are presented in table 2. Of the 10 777 eligible participants, 83 were later found to be <35 or >74 years at the time of the baseline interview and were thus excluded from the cohort. Finally, 10 694 participants participated in the study between November 2018 and September 2019. Among the participants with valid baseline data (ie, completed questionnaire, physical measurements and consent form), blood and urine sample of 95.94% and 98.18%, respectively, were successfully collected, and the mean delay from blood sample collection (with immediate chilling) to sample separation (with immediate freezing) was 2 hours.

In this study, of the 10 694 participants aged 35–74 years, 38.28% were men, and the mean age was 57.98 years. Nearly all were married, and the proportion of having no spouse (mainly widowed) was 1.6 times higher in women than in men (7.68% vs 4.76%), reflecting higher death rates in men than in women. Of the participants, 30.57% had never been to school and the other participants had at least 6 years of formal education. With an increase in age, the probability of education for at least 6 years decreased in both men and women (figure 1A). Nearly 70% of participants earned <12 000¥ per year. At baseline, 96.88% of the patients had a basic health cover. The prevalence of current smokers was higher in men than in women (46.80% vs 35.44%). Among women, the prevalence of current smoking increased rapidly with age and decreased in women aged≥65 years (figure 1B); among men, the prevalence was still>40%. For regular alcohol consumption, the prevalence was much higher in men than in women (34.03% vs 1.61%). Among women, the prevalence of current drinkers was uncommon and varied little by age; among men, the prevalence ranged between 30% and 40% (figure 1C). At baseline, the proportions of regular consumption of coarse cereals (corn), red meat, fish/seafood, fresh vegetables and fresh fruit were 28.79%, 23.84%, 3.94%, 73.60% and 43.87%, respectively (table 2). More than 41% of the participants regularly ate pickled vegetables. Nearly 93.16% of the participants reported using cooking fuel (gas, wood or coal) which emit smoke, and almost all participants used home smoky in winter. Approximately only 2.63% women reported having menarche before the age of 13 years. Nearly all women in the study had given birth, and 9.45% reported having five or more live births. Only 4.48% women reported using contraceptives. Premenopausal women constituted only 21.91% of the female participants. Nearly half of the participants had a high-fat diet that varied little by age, which was similar in women and men (figure 1D). A total of 32.53% of the participants consumed a high-salt diet.

Table 3 presents the characteristics of participants' medical examinations. The mean height of men and women was 164.87 cm and 153.94 cm, respectively. Mean body mass index was 24.74 kg/m^2 in men and 24.65 kg/m^2 in women, with >7.29% being obese (>30 kg/m^2). Mean WC was 89.82 cm and 86.45 cm in men and women, respectively. The mean systolic and diastolic blood pressure at baseline was 140.17/89.87 mmHg in

Table 2 Selected characteristics of participants at baseline in the Environment and Chronic Disease in Rural Areas of Heilongjiang, China, cohort study on environment, diet and chronic disease

Characteristics	Men (n, %)	Women (n, %)	Total (n, %)
Age (years)			
35–44	252 (6.16)	520 (7.88)	772 (7.22)
45–54	1012 (24.73)	2050 (31.06)	3062 (28.63)
55–64	1485 (36.28)	2459 (37.25)	3944 (36.88)
65–74	1344 (32.84)	1572 (23.81)	2916 (27.27)
Mean±SD	59.22±8.85	57.21±8.675	57.98±8.796
Marital status			
Never married	87 (2.13)	30 (0.45)	117 (1.09)
Married	3764 (91.96)	6017 (91.15)	9781 (91.46)
Separated or divorced	47 (1.15)	47 (0.71)	94 (0.88)
Widowed	195 (4.76)	507 (7.68)	702 (6.56)
Highest education completed			
Have never been to school	655 (16.00)	2614 (39.60)	3269 (30.57)
Primary school	1977 (48.30)	2950 (44.69)	4927 (46.07)
Middle school	1039 (25.38)	754 (11.42)	1793 (16.77)
High school or technical secondary school	300 (7.33)	138 (2.09)	438 (4.10)
University or above	122 (2.98)	145 (2.20)	267 (2.50)
Socioeconomic status			
Annual income, whole family (¥/year)			
<12 000	2897 (70.78)	4648 (70.41)	7545 (70.55)
≥12 000	1196 (29.22)	1953 (29.59)	3149 (29.45)
Having health cover	3992 (97.53)	6368 (96.47)	10 360 (96.88)
Smoking history			
Never-smoker	1766 (45.21)	3874 (60.89)	5640 (54.93)
Current smoker*	1828 (46.80)	2255 (35.44)	4083 (39.76)
Ex regular smoker	298 (7.63)	208 (3.27)	506 (4.93)
Missing	14 (0.36)	25 (0.39)	39 (0.38)
Drinking of alcohol			
Never or almost never	1640 (42.06)	5680 (89.62)	7320 (71.51)
regular drinking†	1327 (34.03)	102 (1.61)	1429 (13.96)
Missing	13 (0.33)	18 (0.28)	31 (0.30)
Regular consumption of certain foodstuffs‡			
Coarse cereals (corn)	1070 (27.36)	1889 (29.67)	2959 (28.79)
Red meat and its products	1111 (28.41)	1339 (21.03)	2450 (23.84)
Fish/seafood	163 (4.17)	242 (3.80)	405 (3.94)
Fresh vegetables	2856 (73.02)	4709 (73.96)	7565 (73.60)
Fresh fruit	1678 (42.90)	2831 (44.46)	4509 (43.87)
Pickled vegetables	1642 (41.98)	2592 (40.71)	4234 (41.19)
Exposure to domestic air pollution			
Use of smoky cooking fuel§	1666 (94.61)	5783 (94.23)	7449 (93.16)
Home smoky in winter	3796 (97.84)	6152 (97.48)	9898 (99.50)
Reproductive history in women			
Age at menarche<13 years		167 (2.63)	
Age at first live birth<20 years		542 (8.54)	

Continued

Table 2 Continued

Characteristics	Men (n, %)	Women (n, %)	Total (n, %)
Having five or more live births		600 (9.45)	
Age at menopause<50¶		2134 (42.09)	
Ever used contraceptive pill		284 (4.48)	
High-fat diet**	1869 (47.19)	2985 (46.45)	4854 (46.38)
High-salt diet††	1385 (33.84)	2094 (31.72)	3479 (32.53)

*Current smoker is defined as those who have smoked at least 100 cigarettes lifetime and smoke every day or some days now.
†Regular drinking is defined as at least once a week.
‡Regular consumption of certain foodstuffs is defined as an average of ≧3 times per week in the past year.
§Restricted to participants who reported doing some cooking at home.
¶Restricted to women who were aged 550 years at baseline survey.
**A high-fat diet is defined as an average daily oil intake>25 g.
††A high-salt diet is defined as an average daily salt intake>6 g.

men and 135.67/84.94 mmHg in women. The prevalence of common chronic diseases at baseline included cardiovascular diseases (35.79%), cerebrovascular diseases (12.68%), cancer (0.97%), respiratory diseases (7.37%) and diabetes (6.51%). Compared with women, men had a lower prevalence of these chronic diseases (48.12% vs 52.20%).

Table 4 shows the biochemical characteristics of the participants at the baseline. The mean fasting blood glucose (FBG) was 5.05 mmol/L. The lipid profile included triglycerides (TG), cholesterol (CHOL), high-density lipoprotein (HDL) cholesterol and low-density lipoprotein cholesterol (LDL-CH). The mean TG, CHOL and LDL were higher in women than in men (1.90, 5.74, 3.52 mmol/L vs 1.76, 5.47, 3.34 mmol/L, respectively). Mean HDL levels were similar between men and women.

Table 5 summarises the detection of major chronic diseases. Blood pressure of 10 471 participants was measured, and 50.96% had hypertension. Among the patients, 57.78% with hypertension were newly diagnosed. According to the population composition data of Heilongjiang Province in 2015, the detection rate of standardised hypertension was 52.58% in men and 37.19% in women. With increasing age, the detection rate of hypertension gradually increased, with the highest in 65–74 year age group, and 65.80% in men, and 57.23% in women.

A total of 10 535 participants were tested for FBG, including 5215 with hyperglycaemia. The detection rates of hyperglycaemia and diabetes were 49.50% and 21.55%, respectively. Of the 2261 diabetic patients examined, 528 had a history of diabetes mellitus, and 1733 newly diagnosed diabetic patients accounted for 16.45% of the total

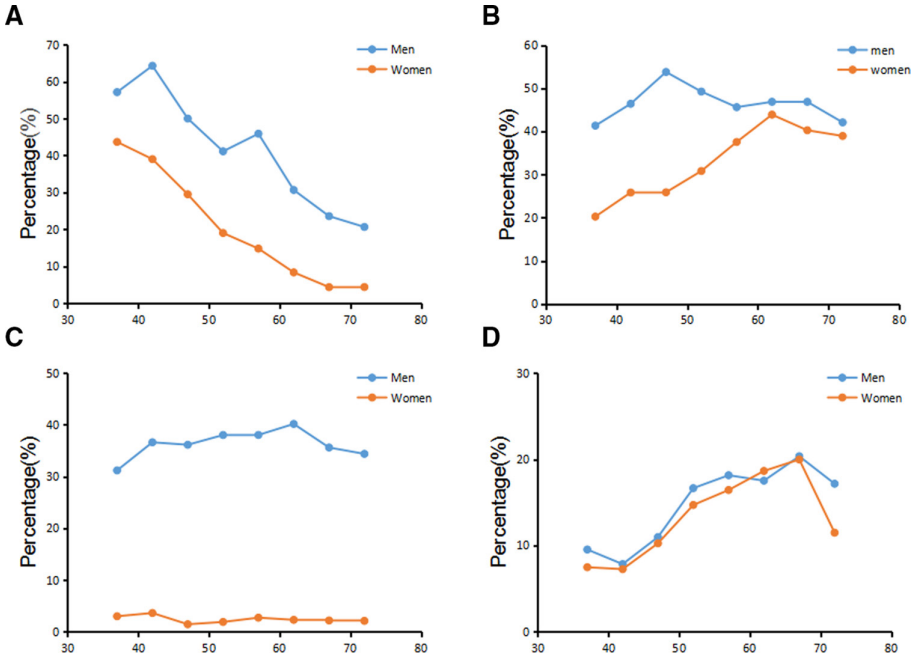

Figure 1 Prevalence of selected baseline variables by sex and by age. (A) Percentage at least 6 years of formal education; (B) percentage current smokers; (C) percentage regular drinking; (D) percentage high fat.

Table 3 Physical examination results for participants in Environment and Chronic Disease in Rural Areas of Heilongjiang, China, cohort study, China

Characteristics	Men (n, %)	Women (n, %)	Total (n, %)
Height (cm)			
<155	200 (5.01)	3471 (53.24)	3671 (34.92)
155–160	525 (13.15)	1949 (29.89)	2474 (23.53)
160–165	1161 (29.08)	893 (13.70)	2054 (19.54)
≥165	2107 (52.77)	207 (3.17)	2314 (22.01)
Mean±SD	164.87±6.61	153.94±5.92	158.09±8.15
Body mass index (kg/m^2)			
<18.5	83 (2.08)	267 (4.10)	350 (3.34)
18.5–25	2110 (52.84)	3319 (50.91)	5429 (51.85)
25–30	1517 (37.99)	2411 (36.98)	3928 (37.52)
≥30	273 (6.84)	490 (7.52)	763 (7.29)
Mean±SD	24.74±3.49	24.65±3.75	24.69±3.65
Waist circumference (cm)			
<80	482 (12.07)	1520 (23.32)	2002 (19.21)
80–89	1457 (36.49)	2592 (39.75)	4049 (38.84)
≥90	2021 (50.61)	2353 (36.09)	4374 (41.95)
Mean±SD	89.82±9.11	86.45±9.56	87.73±9.53
Systolic BP (mm Hg)			
< 120	546 (13.75)	1496 (23.02)	2042 (19.36)
120–139	1534 (38.62)	2490 (38.32)	4024 (38.43)
≥140	1892 (47.63)	2512 (38.66)	4404 (41.74)
Mean±SD	140.17±19.83	135.67±21.02	137.38±20.69
Diastolic BP (mm Hg)			
<80	629 (15.83)	2079 (32.00)	2708 (25.87)
80–89	1402 (35.29)	2336 (35.96)	3738 (35.71)
≥90	1942 (48.88)	2081 (32.04)	4023 (38.43)
Mean±SD	89.87±11.25	84.94±11.39	86.81±11.59
Prior disease history			
Cardiovascular diseases	1328 (34.17)	2332 (36.78)	3660 (35.79)
Cerebrovascular diseases	588 (15.13)	709 (11.18)	1297 (12.68)
Cancer	28 (0.72)	71 (1.12)	99 (0.97)
Respiratory disease	275 (7.08)	479 (7.56)	754 (7.37)
Diabetes	239 (6.15)	427 (6.74)	666 (6.51)
Total	2086 (48.12)	3778 (52.20)	5864 (50.64)

BP, blood pressure.

number of patients and 76.65% of all diabetic patients. According to the population composition data of Heilongjiang province in 2015, the detection rate of standardised hyperglycaemia was 50.34% in men and 42.44% in women; the detection rate of standardised diabetes was 22.85% in men and 15.64% in women. With increasing age, the detection rates of hyperglycaemia and diabetes gradually increased, with the highest in 65–74 years old group in both men (56.19% and 27.72%, respectively) and women (53.45% and 24.76%, respectively).

A total of 10 491 participants were tested for total CHOL, TG, LDL-CH and HDL levels. The abnormal rates of total CHOL, TG, LDL-CH and HDL were 63.90%, 46.81%, 50.79% and 4.99%, respectively. According to the population composition data of Heilongjiang province in 2015, the abnormal rate of standardised total CHOL was 58.00% and 60.31% in men and women, respectively. In women, with increasing age, the abnormal rate of total CHOL gradually increased. It was the highest at 74.87% in the 65–74-year-old group.

Table 4 Selected biochemical characteristics of participants in Environment and Chronic Disease in Rural Areas of Heilongjiang, China, cohort study, China (mean±SD)

Biochemical index	Men	Women	Total
FBG (mmoL/L)	5.13±1.81	5.00±1.75	5.05±1.77
ALP (U/L)	82.76±26.05	91.92±31.67	88.42±29.99
TG (mmoL/L)	1.76±1.24	1.90±1.14	1.85±1.18
CHOL (mmoL/L)	5.47±1.19	5.74±1.24	5.64±1.23
HDL-CH (mmoL/L)	1.57±0.41	1.57±0.35	1.57±0.37
LDL-CH (mmoL/L)	3.34±0.93	3.52±0.98	3.45±0.97
ALT (U/L)	27.90±25.62	23.03±19.66	24.89±22.25
AST (U/L)	31.60±24.35	27.38±15.47	29.00±19.46
GGT (U/L)	58.12±92.52	32.47±41.79	42.26±67.10

ALP, alkaline phosphatase; ALT, alanine transaminase; AST, aspartate amino transferase; CHOL, cholesterol; FBG, fasting blood glucose; GGT, gamma-glutamyl transpeptidase; HDL-CH, high-density lipoprotein cholesterol; LDL-CH, low-density lipoprotein cholesterol; TG, triglycerides.

The abnormal rate of standardised TG was 44.92% and 45.46% in men and women, respectively. With increasing age, the abnormal rate of TG in women tended to increase gradually, and in men, it decreased. The abnormal rate of standardised LDL-CH was 46.38% and 47.07% in men and women, respectively, and the abnormal rate of standardised HDL (detection rate of low HDL) was 7.14% and 4.46% in men and women, respectively. The abnormal rate of LDL-CH changed little with age. With increasing age, the abnormal rate of LDL-CH in women tended to increase gradually, with the highest in the 65–74 years age group. The abnormal rate of HDL (detection rate of low HDL) in women changed little with age, and the highest at 4.71% was in the 35–44-year-old group. With increasing age, the abnormal rate of HDL (the detection rate of low HDL) gradually decreased in men, and the highest rate was 9.09% in the 35–44-year-old group.

A total of 10 696 participants were tested for metabolic syndrome, and the detection rate was 42.63%, including 42.17% and 42.92% in men and women, respectively. According to the population composition data of Heilongjiang province in 2015, the detection rates of standardised metabolic syndrome were 40.15% and 35.91% in men and women, respectively. With increasing age, the detection rate of metabolic syndrome increased gradually in women from 19% to 53%, while in men, except for approximately 35% in the 35–44-year-age group, there

Table 5 Percentage of detection of major chronic diseases

	35–44		45–54		55–64		65–74		Total	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Hypertension*, (%)	39.57	18.53	52.86	38.16	62.31	49.86	65.8	57.23	59.79	45.56
Hyperglycaemia†, (%)	43.62	32.68	51.27	42.48	54.76	49.44	56.19	53.45	53.7	46.92
Diabetes†, (%)	18.11	7,83	23.4	15.03	25.74	21.16	27.72	24.76	25.35	19.06
Dyslipidaemia‡										
TC, (%)	57.44	44.51	57.65	59.61	57.24	72.76	61.97	74.87	58.92	66.96
TG, (%)	52.07	32.75	44.9	46.48	39.66	54.07	37.12	55.88	40.86	50.47
LDL, (%)	47.52	32.94	44.59	45.79	46.21	57.33	48.79	63.5	46.74	53.3
HDL, (%)	9.09	4.71	6.94	4.66	6.14	3.92	4.7	4.46	6.04	4.34
Metabolic syndrome§, (%)	34.52	19.04	42.09	36.01	43.84	47.46	41.82	52.74	42.17	42.92

*Hypertension[27]: systolic blood pressure≥140 mm Hg and/or diastolic blood pressure≥90 mm Hg without using any antihypertensive drugs.
†Hyperglycaemia and diabetes: fasting blood glucose is more than 6.10 mmol/L, diagnosed as hyperglycaemia. Fasting blood glucose was more than 7.0 mmol/L, or had a history of diabetes. Fasting plasma glucose<7.0mmol/L was diagnosed as diabetes.
‡Dyslipidaemia: total TC≥6.22 mmol/L is hypercholesterolaemia, TG≥2.26 mmol/L is hypertriglyceridaemia, LDL cholesterol≥4.14 mmol/L is high-density and low-density lipoprotein cholesterol, and HDL cholesterol≤ 1.04 mmol/L is low-density and high-density lipoprotein cholesterol. TC≥5.17 mmol/L, TG≥1.70 mmol/L, LDL≥3.37 mmol/L, HDL≤1.04 mmol/L can be considered as dyslipidaemia.
§Metabolic syndrome[28]: (1) abdominal obesity (male waist circumference≥90 cm, female waist circumference≥85 cm); (2) elevated blood glucose: fasting blood glucose is more than 6.1 mmol/L and/or has previously diagnosed type 2 diabetes or has received corresponding treatment; (3) elevated blood pressure: systolic blood pressure>130 mm Hg and/or diastolic blood pressure>85 mm Hg, have received corresponding treatment or have previously been diagnosed with hypertension; (4) the level of triglyceride increased: fasting triglyceride≥1.7 mmol/L; (5) the level of HDL cholesterol decreased: fasting HDL cholesterol≤1.04 mmol/l.
HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride.

was little change in other age groups, ranging from 41% and 44%.

By 1 January 2021, 46 people (0.43%) died, 20 (0.19%) were moved and five (0.05%) were lost to follow-up. Overall, based on death and disease registries, 12 new cases of cancer, 9 diabetics, 33 stroke, 6 cardiovascular disease and 7 pulmonary diseases were reported.

Strengths and limitations

The limitations of this study were as follows: (1) Although the study included most of the permanent residents in the villages, the age distribution was higher than that in a similar population-based cohort due to the loss of middle-aged labourers. In another cohort in Harbin,[9] the provincial capital of Heilongjiang province, the mean age was 50 years and only 16.2% participants were over 60 years. Compared with that cohort, the mean age in this study was greater by 6 years, and 27.27% of participants were older than 60 years, and most of the participants were left-behind elderly. The income of farmers in the rural areas of China is extremely limited. To increase family income, middle-aged labourers go outside to work and only return to the countryside during the Chinese New Year. Therefore, only a few middle-aged individuals were included in this study. We excluded populations aged <35 and >74 years which may have limited information on early life exposure.[19] (2) Due to a low percentage of male participants in the cohort, which mainly resulted from the outflow of the male labour force and lower participation rate from men; thus, age- and sex-standardised characteristics in men and women should be considered in the analyses. (3) We relied on self-reported data for some variables, such as lifestyle factors and somatosensory temperature. The somatosensory temperature reflects the human body's perception of outside air temperature, which is related to self-perception and memory. (4) Some studies have pointed out that economic levels affect the prevalence of chronic diseases.[20] Considering that this study was carried out in a lower economic level area, we conducted the second phase of the cohort baseline survey in another county, Dorbod Mongol Autonomous County, which has a better economy in Heilongjiang province.

Despite these limitations, our study is unique. Support from Heilongjiang province enabled us to successfully construct the ECDRAHC, a prospective follow-up investigation in a cohort of adult men and women in China. It was primarily designed to investigate the association between environment (cold weather), diet and chronic diseases in rural areas. First, the ECDRAHC was conducted in Mingshui, which is a county of national-level poverty in Heilongjiang province in China's northeast region. Mingshui is located in a high-latitude zone and is known for long and cold winters. For more than 30 years, the average temperature in winter (from October to April) is 7.2°C with the highest in April (6.2°C) and the lowest in January (−19.2°C). Lower temperatures lead to shortage of fresh vegetables and fruit supplements in the winter. Compared with other studies conducted in the southern area of China, the study participants, both men and women, in ECDRAHC have a higher intake of fat, salt and pickled food, but lower intake of vegetables and fruits.[21–23] In contrast, the incidence of chronic diseases has been reported to be higher in the northern region than in the southern region of China.[9] A higher systolic blood pressure was observed in the ECDRAHC in both men and women. The mean blood pressure was significantly higher than that in Li Liming's survey (137.38±20.69 mm Hg vs 131±21 mm Hg). The age-standardised prevalence of hypertension in our study for all participants, women and men was 32.65%, 37.28% and 30.30%, respectively, whereas those reported by Gao *et al* were 26.6%, 29.2% and 24.1%, respectively.[20] Compared with previous cohort studies, this study revealed that residents in the northern rural region had a higher prevalence of hypertension than those at the national level. Therefore, the ECDRAHC, a representative cohort with a high prevalence of chronic diseases, is useful for investigating the association between cold, diet and chronic diseases. Meanwhile, the results from the ECDRAHC might be valuable for the prevention and treatment of chronic diseases in other populations living in areas with similar high latitude degrees and cold weather worldwide. Second, our study involved individuals who suffered from cold weather and air pollution due to the use of smoke emitting cooking fuel and home smoky in winter. This would allow one to conduct comparative studies on the effects of various environmental exposures on the outcome of people's health from different perspectives. Third, detailed and comprehensive information was collected in baseline survey. We have generally followed the WHO STEPS guidelines in the research.[24–26] For instance, in addition to demographics, socioeconomics, lifestyles and health-related histories, we collected biological specimens and performed medical examinations and clinical laboratory tests for every participant. Fourth, the ECDRAHC was supported by the government, and follow-up information will be obtained through annual data linked to electronic records of disease and death registries as well as reinterviews every 2 years. This follow-up strategy enables the accurate and reliable tracking of exposures and outcomes. Fifth, we did a lot of publicity work before conducting the survey, explaining the survey process in detail on the spot and received strong support from local residents. When participants were reluctant to complete further investigations, they were excluded from cohort studies. Simultaneously, we carried out quality control on-site, and when there was a missing project, timely verification was performed to avoid data loss. Thus, the problem of low response rate was avoided, and participants in the cohort agreed to complete the survey.

The results of the baseline survey showed that the detection rates of hypertension, diabetes, hyperlipidaemia and metabolic syndrome were relatively high. In addition, according to the history of disease reported by the respondents, more cases of hypertension and diabetes were found. Therefore, prevention and control

plans should be formulated for key chronic diseases. The results of this baseline survey show that in terms of bad lifestyle, the smoking and drinking rate is high; in terms of unbalanced diet, for example, the proportion of people using excessive edible oil is relatively high. In addition, the rates of overweight and obesity are high, especially the overweight rate. These factors are important risk factors affecting the high incidence of major chronic diseases such as cardiovascular and cerebrovascular diseases. Therefore, active promotion of comprehensive prevention and treatment strategies for key risk factors of chronic diseases is suggested.

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