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Are Both Individual-level and Community-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

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4 **Are Both Individual-level and Community-level Social Capital**
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6 **Associated with Individual Health? A Serial Cross-Sectional**
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8 **Analysis in China, 2010-2015**
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Are Both Individual-level and Community-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

ABSTRACT

Background The association between multilevel social capital and individual health has been previously shown to be inconsistent in the literature; moreover, little is known about their association over time. We aimed to examine the associations of both individual-level and community-level social capital with individual health in China during a period of rapid economic growth.

Methods We conducted a serial cross-sectional study using data of 42,829 Chinese adults (age ≥ 18 years) from the 2010, 2012, 2013, and 2015 Chinese General Social Survey. Information on respondents' self-rated physical and mental health was collected in all time points. We assessed social capital by individual-level and community-level indicators, including frequency of socializing, civic participation, and trust. We conducted multilevel binary logistic regression models to examine the associations of individual-level and community-level social capital with self-rated physical and mental health.

Results Individual-level social capital in terms of high frequency of socializing and high trust were significantly associated with good physical and mental health in all years. No evidence showed that the associations of individual-level frequency of socializing and trust with physical and mental health changed over time. There were no consistent associations of individual-level civic participation or any community-level social capital indicators with physical or mental health.

Conclusion The positive associations of individual-level social capital in terms of socializing and trust with physical and mental health were robust during a period of rapid economic growth. Improving individual-level socializing and trust for health promotion could be a long-term strategy even within a rapidly developing society.

Strengths and limitations of this study

- A major strength of our study is the comparability of the associations between multilevel social capital and health outcomes over time. Hence, our consistent findings provided more solid evidence for associations of the individual-level frequency of socializing and trust with physical and mental health beyond previous mixed results.
- The other strength of our study is that we took advantage of a rapidly developing society (i.e., China) as a social laboratory to observe the associations between multilevel social capital and health outcomes.
- A limitation of our study is that we cannot make causal inferences since this study is cross-sectional by nature.
- We only included generalized trust in cognitive social capital.
- The study period was relatively short (i.e., six years), which prohibited us from observing a more long-term trend of the association.

INTRODUCTION

Social capital, defined as resources available to members of social groups and resources embedded within an individual's social networks,^{1,2} is a critical social determinant in shaping population health. Although debates are ongoing as to whether social capital is an individual attribute or a collective property, previous public health studies suggested that the individual and collective perspectives were not mutually exclusive and might affect individuals' health simultaneously.^{3,4} From an individual perspective, social capital affects health by providing informational, emotional, and instrumental support. From a collective perspective, social capital affects health by facilitating collective action, maintaining social norms, and enhancing reciprocity.^{5,6}

An increasing number of studies employed a multilevel analytical framework to examine the associations of both individual-level and collective-level social capital with health. Nevertheless, results from these multilevel studies were mixed.^{3,7-10} Most of these studies found that at least one indicator of each level of social capital was associated with health. Some studies only showed an association between individual-level social capital and health, while a handful of studies suggested that only collective-level social capital was associated with health. Although most of these studies indicated that social capital was beneficial for health, several studies reported negative associations between higher levels of social capital and better health.¹¹⁻¹³ Even studies within the same countries (e.g., Japan^{12,14} and China^{13,15}) showed inconsistent results in terms of the directions of the associations between social capital and health.

The above-mentioned inconsistent results may be due to different operationalizations of social capital, different study time points, or both. Although different operationalizations of social capital provided insights to understand what specific social capital indicator was beneficial for health among a spectrum of social capital measures, they made it difficult to make meaningful comparisons between studies and to examine whether the association between social capital and health was consistent over time. A newly published study in Montreal, Canada only examined the association of individual-level social capital with health over time.¹⁶ Additionally, as Montreal is only a representative of developed society, the results may not be applicable in a rapidly developing society.

Hence, we examined the associations of both individual-level and community-level social capital with health over time in China. China is an ideal setting for this study since it has experienced rapid economic development over the past four decades. Its gross domestic product (GDP) increased rapidly from 1.8% of the global economy in 1978 to 15% in 2018.¹⁷ This rapid economic transition allows us to use a relatively short period to observe whether the association between multilevel social capital and health changed with socioeconomic development. It also allows us to compare the difference in the change of association of multilevel social capital with health between the traditionally long-term developed western societies and those with more recent and rapid economic development.

We specifically examined: (1) how individual-level social capital, community-level social capital, and health changed during a period of rapid economic growth; (2) what the associations of individual-level and community-level social capital with health were in each survey year; (3) whether the associations changed during a period of rapid economic growth.

METHODS

Data source and participants

We collected data from the 2010, 2012, 2013, and 2015 waves of the Chinese General Social Survey (CGSS), which is publicly available. The participants were Chinese adults aged 18 years or above. Health outcomes, social capital, sociodemographic, and socioeconomic factors were consistently collected throughout the four years. The CGSS is a national representative survey project in Mainland China conducted by the Renmin University of China.

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3 The sampling strategy was described in further details in a previous study.¹³
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6 **Measurements**

7 **Health outcomes**

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10 Health outcomes were self-rated physical and mental health. For physical health, respondents answered the
11 question “How do you think about your current physical health?” Responses were divided into “poor” (including
12 “very unhealthy”, “unhealthy”, and “neutral”) and “good” (including “healthy” and “very healthy”) physical
13 health. For mental health, respondents answered the question “During the past four weeks, how often have you
14 felt depressed or frustrated?” Responses were categorized into “poor” (including “always”, “often”, and
15 “sometimes”) and “good” (including “seldom” and “never”) mental health. The two self-rated health indicators
16 were used in previous studies.^{18–20}
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20 **Social capital**

21
22 Social capital can be separated into structural and cognitive dimensions. Structural social capital refers to actual
23 network connections and civic engagement while cognitive social capital refers to perceptions of trust and norms.³
24 We measured individual-level structural social capital by respondents’ frequency of socializing (high, low) and
25 civic participation (yes, no). We measured individual-level cognitive social capital by respondents’ trust of others
26 (high, low). Details of the questions are shown in Supplementary Material 1.
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29 We aggregated individual-level social capital responses to the county level as community-level social capital.
30 Specifically, we calculated the percentages of people with “high” frequency of socializing, of those with “yes”
31 regarding civic participation, and of those with “high” trust in each county. Higher percentages indicated higher
32 community-level social capital.
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36 **Sociodemographic and socioeconomic factors**

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38 We included gender (male, female), age (years), ethnicity (*Han*, non-*Han*), and marital status
39 (married/cohabitation, never married/divorced/separated/widowed) as sociodemographic factors, and education
40 (primary school or below, junior secondary school, senior secondary school, and college or above), occupation,
41 poverty, and places of residence (rural, urban) as socioeconomic factors. Details of the occupation and poverty
42 are shown in Supplementary Material 2.
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46 **Statistical analysis**

47 We reported weighted means with standard deviations (SD) for continuous variables and weighted percentages
48 for categorical variables. We calculated individual weighting factors by the distribution of gender, age, and place
49 of residence according to the 2010 China population census data,²¹ and community weighting factors according
50 to the distribution of the numbers of counties in each province in 2010 based on the China Statistical Yearbook
51 2011.²² To examine how social capital and health changed over time, following the methodology as in previous
52 studies,^{23,24} we assessed the trends of health and individual-level social capital by binary logistic regression models
53 with the calendar year being the independent variable. The results of the regressions indicated whether the health
54 variations and the individual-level social capital variations between years were statistically significant. Similarly,
55 with the calendar year as the independent variable, we assessed the trends of community-level social capital by
56 linear regression models.
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To examine the associations of individual-level and community-level social capital with health, we employed two-level binary logistic regression models adjusting for sociodemographic and socioeconomic factors. We compared the results of regression models with weighted and unweighted data as a robustness check. The weighting method is shown in Supplementary Material 3. To examine whether the associations of social capital with physical and mental health changed over time, we performed interaction tests between statistically significant social capital indicators and survey year.

We used Stata/MP 14.2 to conduct all data analysis with a two-tailed p -value < 0.05 as the significance level.

RESULTS

Our study included a total of 42,829 respondents. Specifically, there were 10,827 respondents nested in 133 counties in 2010, 11,104 in 131 counties in 2012, 10,663 in 126 counties in 2013, and 10,235 in 130 counties in 2015. Table 1 presents the weighted sample characteristics in 2010, 2012, 2013, and 2015 (The missing data values are listed in online supplementary table 1. The unweighted results are shown in online supplementary table 2). Generally, the percentages of good physical and mental health fluctuated over the study period, but both the percentages were lowest in 2012 and peaked in 2013. For individual-level social capital, high frequency of socializing increased generally and peaked in 2013; civic participation peaked in 2012 and reached the lowest level in 2013; high trust decreased to the bottom in 2013 and then slightly rebounded in 2015. For community-level social capital, the percentage of high frequency of socializing increased; the percentage of civic participation peaked in 2012 and dropped to the bottom in 2013; the percentage of trust decreased from 2010 to 2013 and then increased in 2015.

[Table 1 here]

Figure 1 shows the trends of physical and mental health, individual-level social capital, and community-level social capital over time. Figure 1a indicates that the likelihood of good physical health in 2012 (odds ratio (OR) 0.95, 95% confidence interval (CI) 0.89–1.00) was marginally significantly ($p = 0.062$) lower than that in 2010 (reference). However, this likelihood in 2013 (OR 1.31, 95% CI 1.24–1.40) and 2015 (OR 1.21, 95%CI 1.13–1.28) was significantly higher than that in 2010. The likelihood of good mental health in 2013 (OR 1.30, 95%CI 1.22–1.38) and 2015 (OR 1.13, 95%CI 1.06–1.21) were also significantly higher than that in 2010. No significant difference in mental health was observed between 2010 and 2012.

Figure 1b shows that the likelihood of high frequency of socializing in 2012 (OR 1.28, 95%CI 1.19–1.37), 2013 (OR 1.34, 95%CI 1.25–1.43), and 2015 (OR 1.31, 95%CI 1.22–1.41) were significantly higher than that in 2010. The likelihood of civic participation in 2012 (OR 1.07, 95%CI 1.01–1.14) was significantly higher than that in 2010. However, it decreased and became significantly lower in 2013 (OR 0.90, 95%CI 0.84–0.95) than that in 2010. No evidence showed that the likelihood of civic participation in 2015 was significantly different from that in 2010. The likelihood of high trust in 2012 (OR 0.92, 95%CI 0.87–0.98), 2013 (OR 0.67, 95%CI 0.63–0.71), and 2015 (OR 0.90, 95%CI 0.84–0.96) was significantly lower than that in 2010.

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4 Figure 1c shows that community-level frequency of socializing in 2012 ($\beta = 4.64$, 95%CI 1.73–7.54), 2013 (β
5 = 7.58, 95%CI 4.57–10.59), and 2015 ($\beta = 8.22$, 95%CI 5.28–11.16) were significantly higher than that in 2010.
6
7 No evidence showed that community-level civic participation significantly changed over time. Community-level
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9 trust in 2013 ($\beta = -9.59$, 95%CI -12.57– -6.61) was significantly lower than that in 2010. No evidence showed
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11 that community-level trust in 2012 or 2015 was significantly different from that in 2010.
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15 *[Figure 1 here]*
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18 Table 2 shows the associations of both individual-level and community-level social capital with physical health.
19 Among the individual-level social capital indicators, high frequency of socializing (2010: OR 1.49, 95%CI 1.33–
20 1.66; 2012: OR 1.40, 95%CI 1.26–1.54; 2013: OR 1.28, 95%CI 1.15–1.42; 2015: 1.36, 95%CI 1.22–1.50) and
21 high trust (2010: OR 1.33, 95%CI 1.21–1.46; 2012: OR 1.30, 95%CI 1.19–1.42; 2013: OR 1.22, 95%CI 1.11–
22 1.34; 2015: OR 1.41, 95%CI 1.28–1.55) were significantly associated with good physical health in all years. No
23 evidence supported that there was a significant association between civic participation and physical health after
24 adjustment in any year. Among community-level social capital indicators, after adjustment, higher percentages of
25 frequency of socializing and trust were significantly positively associated with good physical health in 2015
26 (socializing: OR 1.01, 95%CI 1.01–1.02; trust: OR 1.01, 95%CI 1.01–1.02). In contrast, a higher percentage of
27 civic participation was significantly negatively associated with good physical health in 2015 (OR 0.99, 95%CI
28 0.99–1.00); nevertheless, the ORs were close to one.
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33 *[Table 2 here]*
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36 Table 3 presents the associations of both individual-level and community-level social capital with mental health.
37 The associations were similar to that of social capital with physical health in terms of directions and significance.
38 Among individual-level social capital indicators, high frequency of socializing (2010: OR 1.26, 95%CI 1.13–
39 1.40; 2012: OR 1.20, 95%CI 1.09–1.33; 2013: OR 1.30, 95%CI 1.17–1.45; 2015: 1.36, 95%CI 1.22–1.50) and
40 high trust (2010: OR 1.47, 95%CI 1.34–1.61; 2012: OR 1.43, 95%CI 1.30–1.56; 2013: OR 1.36, 95%CI 1.24–
41 1.50; 2015: OR 1.43, 95%CI 1.30–1.56) were significantly associated with good mental health. Civic participation
42 was only positively associated with good mental health in 2013 (OR 1.17, 95%CI 1.06–1.29). No significant
43 association between any community-level social capital indicator and mental health in the four years was observed.
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48 *[Table 3 here]*
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50 As for sociodemographic and socioeconomic factors, being male sex, non-poor, and having a higher education
51 level were significantly associated with good physical and mental health in all years. Being older was negatively
52 associated with good physical and mental health in all years. Additionally, being non-employed was significantly
53 associated with a lower likelihood of having good physical health comparing with having occupations at Skill
54 level 3 or 4 (reference) in all years, but not significantly associated with mental health. Being married or cohabiting
55 was significantly associated with good mental health in all years, but not associated with physical health.
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57 The results stratified by place of residence (i.e., rural and urban) showed similar patterns to the results from the
58 whole sample in each year in terms of the associations of individual-level frequency of socializing and trust with
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3 physical and mental health (online supplementary table 3 and 4). The results from the pooled data between 2010
4 and 2015 also showed that individual-level social capital in terms of frequency of socializing and trust was
5 associated with physical and mental health after adjustment (online supplementary table 5).
6

7 We further examined the interactions between consistently significant social capital indicators (i.e., individual-
8 level frequency of socializing and trust) and survey year (online supplementary table 6). The interactions were
9 not significant; i.e., no evidence supported that the associations of the individual-level frequency of socializing
10 and trust with physical and mental health changed over time.
11

12 We repeated the two-level binary regression models based on the whole weighted sample of each year (i.e.,
13 Table 2 and Table 3). The associations between both levels of social capital and health outcomes (online
14 supplementary table 7 and 8) were similar to our unweighted results in Table 2 and Table 3.
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17 **DISCUSSION**

18 **Main findings**

19 To our knowledge, this is the first serial cross-sectional study in China examining the associations of multilevel
20 social capital with individuals' physical and mental health with nationally representative data. We found that the
21 likelihood of having good physical and mental health fluctuated during a period of rapid economic development;
22 in other words, the likelihood of having good physical and mental health did not consistently increase with
23 economic growth during this study period. Among the indicators of individual-level social capital, in general, the
24 likelihood of high frequency of social socializing increased, the likelihood of civic participation fluctuated, and
25 the likelihood of high trust decreased during the survey period. Among the indicators of community-level social
26 capital, in general, the percentage of high frequency of socializing increased, the percentage of civic participation
27 did not change significantly, and the percentage of high trust decreased in 2013 significantly. We also found that
28 higher levels of individual-level social capital in terms of frequency of socializing and trust were consistently
29 associated with good physical and mental health during the period of rapid economic development. However, we
30 did not find evidence for a consistent association of any community-level social capital indicator with physical or
31 mental health during the same period.
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38 **Interpretations**

39 Putting all the results together, our study suggests that no matter how people's physical and mental health changed
40 during a period of rapid economic growth, individual-level social capital in terms of socializing and trust
41 consistently played a pivotal role in protecting individuals' physical and mental health. Under such circumstances,
42 the decreased trend in individual-level trust within the observed period indicated that we should especially pay
43 attention to improve people's trust for health promotion.
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46 The provision of informational, instrumental, and emotional support may be plausible reasons why the
47 individual-level frequency of socializing was associated with our health outcomes.^{6,25} Socializing helps maintain
48 and extend individuals' social networks, from which individuals can obtain monetary, material and mental
49 assistance, and health-rated information. Additionally, a higher frequency of socializing is beneficial for mental
50 health by fulfilling the human need for social connectedness, increasing people's sense of belonging, and reducing
51 the perceived isolation.²⁶ Moreover, people with high trust are more likely to consider healthcare systems and
52 health-related information as trustful social resources,^{27,28} and more likely to perceive emotional support.²⁹ They
53 also have less sense of social anxiety.³⁰
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56 We argue that some of the mechanisms above are unchanged in a rapidly developing society, resulting in the
57 observed consistent associations of individual-level socializing and trust with physical and mental health. First, a
58 rapidly developing economy is almost always accompanied by social change. Under such circumstances, the old
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3 formal health-related institutions and information channels may not fulfill people's needs while the new ones may
4 not be completely established or may not operate stably. Hence, people need to obtain support from informal
5 channels, such as family members, friends, and acquaintances. Second, a rapidly developing society is often
6 accompanied by technological innovation and information explosion. An individual is almost unlikely to know
7 all about new health-related technology and information on his or her own. In this light, socializing could reduce
8 individuals' costs to learn new health-related technology and obtain new information through social networks.
9 Also, people with a high trust may be more likely to consider emerging health-related institutions, technology,
10 and information in a rapidly developing society as trustworthy, and are thus more willing to use them. An example
11 is online prescription drug services. A study in the United States found that people with higher trust had a higher
12 intention of adopting online prescription drug services.³¹ Additionally, a rapidly developing society may also be
13 accompanied by high social mobility and great social uncertainty, whereby people do not have enough information
14 to predict others' behaviors.³² In such a situation, people with a high trust of others are less likely to worry about
15 others' intention to harm them; hence, they might suffer from less anxiety.

16
17 On the other hand, we did not find consistent associations of individual-level civic participation with physical
18 and mental health. Previous studies showed mixed associations between individual-level civic participation and
19 health outcomes.^{29,33,34} We measured civic participation by voting in the neighborhood/village committee election.
20 Previous studies argued that local political participation (e.g., voting) could affect welfare policies provided by
21 governments.^{35,36} Nevertheless, neighborhood/village committees in China have no right to make policies.
22 Additionally, voting is a social- and political-specific indicator for civic participation, which may result in
23 inconsistent associations between civic participation and health in different societies.

24
25 We also did not find consistent associations of any community-level social capital indicators with physical or
26 mental health. Previous studies showed mixed results as to the associations between community-level social
27 capital and health.^{29,33,34,37} The mixed results may be due to different geographic scales where study areas were
28 located. For example, studies in the UK defined communities as post-code sectors,^{34,38} while studies in the US
29 measured community-level social capital at the state level.^{35,39} While a previous Chinese study measured
30 community-level social capital at the village level,²⁹ the present study measured community-level social capital
31 at the county level. Also, the social capital indicators in these studies were not the same; hence, it is difficult to
32 make meaningful comparisons with other studies.

40 41 **Strengths and limitations**

42 A major strength of our study is the comparability of the associations between multilevel social capital and health
43 outcomes over time. Hence, our consistent findings provided more solid evidence for associations of the
44 individual-level frequency of socializing and trust with physical and mental health beyond previous mixed results.
45 The other strength of our study is that we took advantage of a rapidly developing society (i.e., China) as a social
46 laboratory to observe the associations between multilevel social capital and health outcomes.

47
48 A limitation of our study is that we cannot make causal inferences since this study is cross-sectional by nature.
49 However, our health outcomes were "current" physical health and mental health in the "past four weeks", and our
50 frequency of socializing was socializing "in the past year". The timeline helped us partially avoid reverse
51 associations between individual-level frequency of socializing and health outcomes. Secondly, we only included
52 generalized trust in cognitive social capital. While this measurement cannot directly capture community-specific
53 trust (e.g. trust in neighbors), it was used in previous studies.^{34,37,39,40} Thirdly, the study period was relatively short
54 (i.e., six years), which prohibited us from observing a more long-term trend of the association. However, as we
55 observed the association in a rapidly developing and changing society and the development and changes are
56 ongoing, we speculate that the associations we observed will remain in the long run.

Conclusion

Our findings suggest that individual-level social capital in terms of frequency of socializing and trust is a robust social determinant of health during a period of rapid economic growth. Hence, improving individual-level social capital for health promotion could be a long-term strategy even in a rapidly developing society. Interventions can be designed to increase opportunities for socializing and to improve trust. Given that people with less socializing and lower trust appear to be at a higher risk of poor health, interventions could consider a population segmentation strategy based on social capital indicators to target individuals with lower frequency of socializing and lower trust. It may be difficult for policies to target individuals directly, but they can be designed as a “nudge” for individuals’ socializing and trust. For example, governments can consider providing freely accessible public space (e.g., parks, activity centers) for people’s social interaction, and they can also extend operation hours of public transports to encourage socialization. Trustworthy health-related information channels should also be established. On the other hand, policymakers may pay attention to avoid damaging social capital when implementing other policies.

Contributors YH was responsible for literature review, study design, data analysis, data interpretation, and drafting the manuscript. RY-NC oversaw the whole study and was responsible for literature review, study design, data interpretation and write-up of the manuscript.

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Competing interests We declare no competing interests.

Patient and public involvement Patients and/or the public were not involved in this research.

Patient consent for publication Not required.

Ethics approval No ethics review was needed for these secondary analyses of publicly available, anonymized data

Data availability statement The secondary data are available from Chinese National Survey Data Archive.

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Table 1. Sample Characteristics, 2010-2015

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	36.43	37.75	30.36	32.21
Good	63.57	62.25	69.64	67.79
Mental Health				
Poor	32.83	33.03	27.35	30.19
Good	67.17	66.97	72.65	69.81
Sociodemographic factors				
Gender				
Female	49.48	49.48	49.48	49.48
Male	50.52	50.52	50.52	50.52
Age (years)	42.76±16.35	42.76±16.39	42.74±16.36	42.74±16.38
Ethnicity				
Non-Han	9.97	9.82	9.64	8.68
Han	90.03	90.18	90.36	91.32
Marital status				
Single/separated/divorced/widowed	24.16	24.40	25.17	25.78
Cohabit/married	75.84	75.60	74.83	74.22
Socioeconomic factors				
Education				
Primary school or below	33.77	32.50	31.25	29.95
Junior secondary school	31.33	30.04	30.89	30.75
Senior secondary school or equal	19.35	19.85	19.64	19.66
College or above	15.55	17.62	18.22	19.64
Occupation [#]				
Skill 3 or 4	10.62	13.40	11.93	11.88
Skill 2	53.53	51.75	51.15	47.33
Skill 1	3.58	2.71	3.40	4.56
Non-employed	32.27	32.14	33.52	36.22
Poverty				
Poor	11.59	15.23	13.24	14.71
Non-poor	81.08	76.44	77.79	79.76
Do not know income	7.33	8.33	8.97	5.53
Place of residence				
Urban	51.76	51.76	51.76	51.76
Rural	48.24	48.24	48.24	48.24
Social capital				
Frequency of socializing				
Low	77.11	72.51	71.58	71.94

High	22.89	27.49	28.42	28.06
Civic participation				
No	55.78	54.06	58.48	56.44
Yes	44.22	45.94	41.52	43.56
Trust				
Low	35.44	37.34	45.13	37.92
High	64.56	62.66	54.87	62.08
Community level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	20.93±9.33	25.57±10.16	28.51±11.93	29.15±11.10
Civic participation (%)	48.16±19.55	50.27±18.20	45.05±17.80	47.63±17.94
Trust (%)	66.78±9.68	64.56±12.00	57.19±11.38	64.40±8.49

Weighted percentages for categorical variables and weighted means for continuous variables with standard deviations

Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations (for more details, please see Supplementary Material 2).

Table 2. Associations of individual-level and community-level social capital with physical health, 2010-2015
(Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.31*** (1.20,1.43)	1.30*** (1.19,1.42)	1.20*** (1.09,1.32)	1.31*** (1.19,1.43)
Age				
	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)
Ethnicity				
Non-Han	1	1	1	1
Han	0.90 (0.73,1.10)	1.02 (0.84,1.24)	0.94 (0.77,1.16)	1.10 (0.89,1.35)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.01 (0.90,1.14)	0.90 (0.81,1.01)	1.02 (0.90,1.14)	0.93 (0.83,1.04)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.18** (1.05,1.33)	1.20** (1.07,1.34)	1.27*** (1.13,1.43)	1.12 (1.00,1.26)
Senior secondary school or equal	1.32*** (1.15,1.52)	1.39*** (1.21,1.59)	1.49*** (1.28,1.73)	1.40*** (1.21,1.62)
College or above	1.43*** (1.19,1.72)	1.51*** (1.26,1.79)	1.59*** (1.31,1.93)	1.60*** (1.32,1.94)
Poverty				
Poor	1	1	1	1
Non-poor	1.59*** (1.38,1.83)	1.68*** (1.48,1.90)	1.64*** (1.43,1.87)	1.55*** (1.37,1.76)
Do not know income	1.55*** (1.24,1.93)	1.43*** (1.17,1.74)	1.49*** (1.22,1.81)	1.31* (1.05,1.64)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.89 (0.74,1.07)	0.94 (0.80,1.11)	0.94 (0.78,1.13)	0.96 (0.79,1.17)
Skill level 1	1.19 (0.89,1.58)	1.03 (0.77,1.36)	0.99 (0.74,1.34)	0.87 (0.66,1.16)
Non-employed	0.66*** (0.55,0.80)	0.76** (0.65,0.90)	0.63*** (0.52,0.76)	0.76** (0.63,0.93)
Place of residence				

Rural	1	1	1	1
Urban	1.08	1.12	1.28***	1.29***
	(0.96,1.22)	(1.00,1.25)	(1.14,1.45)	(1.15,1.46)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.49***	1.40***	1.28***	1.36***
	(1.33,1.66)	(1.26,1.54)	(1.15,1.42)	(1.22,1.50)
Civic participation				
No	1	1	1	1
Yes	1.01	1.01	1.01	0.99
	(0.91,1.11)	(0.92,1.11)	(0.91,1.11)	(0.90,1.09)
Trust				
Low	1	1	1	1
High	1.33***	1.30***	1.22***	1.41***
	(1.21,1.46)	(1.19,1.42)	(1.11,1.34)	(1.28,1.55)
Community-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.00	1.01***
	(0.98,1.00)	(0.99,1.01)	(0.99,1.01)	(1.01,1.02)
Civic participation (%)				
	1.00	1.00	0.99	0.99**
	(0.99,1.00)	(0.99,1.00)	(0.99,1.00)	(0.99,1.00)
Trust (%)				
	1.00	1.00	1.00	1.01*
	(0.99,1.01)	(1.00,1.01)	(0.99,1.01)	(1.00,1.02)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

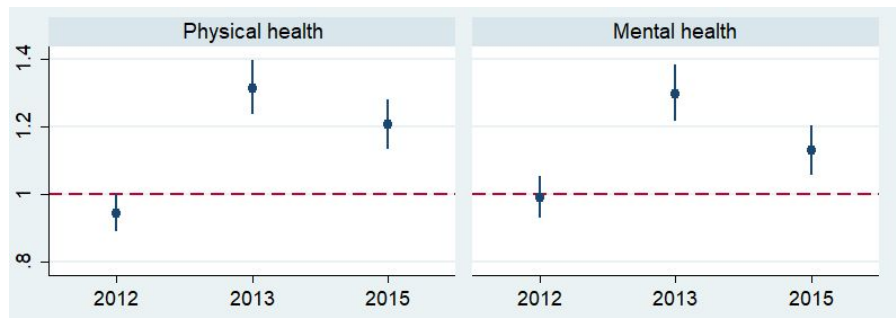
Table 3. Associations of individual-level and community-level social capital with mental health, 2010-2015 (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24***	1.32***	1.11*	1.25***
	(1.14,1.35)	(1.21,1.44)	(1.01,1.22)	(1.14,1.37)
Age	0.99***	0.99***	0.99***	0.99***
	(0.99,0.99)	(0.99,1.00)	(0.99,0.99)	(0.99,1.00)
Ethnicity				
Non-Han	1	1	1	1
Han	0.86	1.05	0.94	1.00
	(0.70,1.04)	(0.87,1.27)	(0.76,1.15)	(0.81,1.23)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.26***	1.21***	1.29***	1.21***
	(1.12,1.40)	(1.09,1.35)	(1.15,1.44)	(1.08,1.35)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.35***	1.24***	1.23***	1.28***
	(1.20,1.51)	(1.11,1.39)	(1.09,1.39)	(1.13,1.44)
Senior secondary school or equal	1.44***	1.53***	1.37***	1.62***
	(1.25,1.66)	(1.33,1.76)	(1.17,1.59)	(1.40,1.89)
College or above	1.58***	1.51***	1.51***	1.71***
	(1.32,1.90)	(1.26,1.79)	(1.25,1.83)	(1.42,2.07)
Poverty				
Poor	1	1	1	1
Non-poor	1.80***	1.77***	1.77***	1.54***
	(1.57,2.06)	(1.57,1.99)	(1.55,2.02)	(1.37,1.74)
Do not know income	1.89***	1.55***	1.36**	1.38**
	(1.53,2.34)	(1.29,1.88)	(1.13,1.64)	(1.11,1.71)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	1.02	1.01	1.03	1.21
	(0.85,1.21)	(0.86,1.19)	(0.86,1.23)	(1.00,1.46)
Skill level 1	1.17	0.99	1.04	1.13
	(0.88,1.54)	(0.74,1.32)	(0.77,1.40)	(0.86,1.50)
Non-employed	0.94	1.04	0.92	1.05
	(0.79,1.13)	(0.89,1.23)	(0.77,1.11)	(0.87,1.27)
Place of residence				

Rural	1	1	1	1
Urban	1.08	1.00	1.07	1.17**
	(0.96,1.21)	(0.89,1.12)	(0.95,1.20)	(1.04,1.32)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.26***	1.20***	1.30***	1.36***
	(1.13,1.40)	(1.09,1.33)	(1.17,1.45)	(1.22,1.50)
Civic participation				
No	1	1	1	1
Yes	0.99	1.05	1.17**	1.02
	(0.90,1.09)	(0.96,1.15)	(1.06,1.29)	(0.92,1.13)
Trust				
Low	1	1	1	1
High	1.47***	1.43***	1.36***	1.43***
	(1.34,1.61)	(1.30,1.56)	(1.24,1.50)	(1.30,1.56)
Community-level social capital				
Frequency of socializing (%)				
	1.00	1.00	1.00	1.00
	(0.99,1.01)	(0.99,1.01)	(0.99,1.01)	(0.99,1.01)
Civic participation (%)				
	1.00	1.00	1.00	1.00
	(1.00,1.01)	(1.00,1.01)	(0.99,1.00)	(0.99,1.00)
Trust (%)				
	1.00	1.01	1.00	1.00
	(0.99,1.01)	(1.00,1.02)	(0.99,1.01)	(0.99,1.01)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

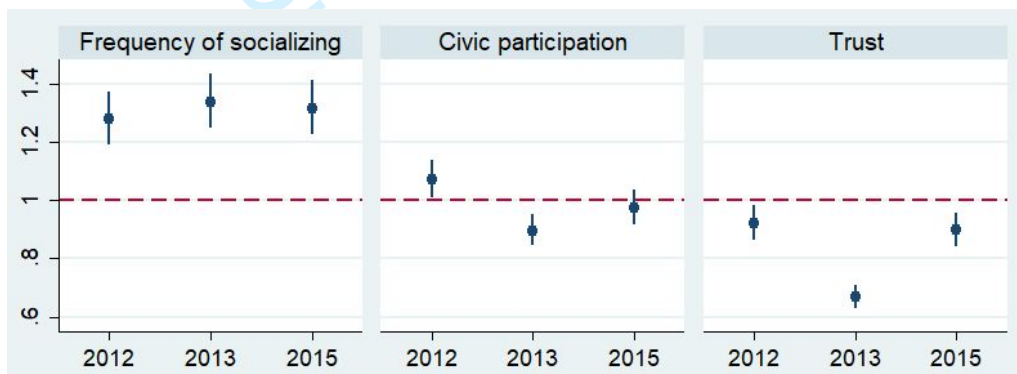
* p < 0.05, ** p < 0.01, *** p < 0.001

Fig. 1 Trends of health outcomes, individual-level social capital and community-level social capital, 2010-2015



ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; “poor” physical health and “poor” mental health were references of the dependent variables in each model

Fig. 1a Trends of health outcomes, 2010-2015 ($N=42,829$)



ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; “low” frequency of socializing, “low” trust and “no” civic participation were references of the dependent variables in each model

Fig. 1b Trends of individual-level social capital, 2010-2015 ($N=42,829$)



Coefficients (β) with 95% CI were reported with 2010 as the reference year based on linear regression models

Fig. 1c Trends of community-level social capital, 2010-2015 ($N=520$)

Supplementary Materials and Data

Supplementary Material 1: Details of the questions for social capital indicators

Frequency of socializing We assessed respondents' frequency of socializing by the question "How often did you engage in social interactions in your spare time in the past year?" Responses were categorized into "low" (including "never", "seldom", and "sometimes") and "high" (including "often" and "very frequently") frequency.

Civic participation We assessed civic participation by the question "Did you vote in the latest neighborhood/village committee election?". According to related laws,^{1,2} neighborhood committees and village committees are the basic-level administrative units, and residents aged 18 or above in each neighborhood/village directly elect members to the two committees. Hence, voting in the election reflects people's willingness to participate in civic activities in a community. The voting rate in a community reflects the extent of a community's social cohesion, and this measurement has been used in several previous studies.³⁻⁶

Trust We measured respondents' trust of others based on the question "Generally speaking, do you agree that most people in the society are trustworthy?" Responses were categorized into "low" (including "strongly disagree", "disagree", and "neutral") and "high" (including "agree" and "strongly agree") trust.

Supplementary Material 2: Details of occupation and poverty

We classified occupation according to the International Standard Classification of Occupations 2008 (ISCO-08) (i.e., Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations).⁷ We further included students, the unemployed, and retired people as "non-employed."

We assessed poverty by equivalized household income, which was calculated by dividing household income by the squared root of the number of household members. We defined respondents as "poor" if their equivalized household annual incomes were less than or equal to half of the median equivalized household annual income in each survey year. We further included "do not know income" as a separate category.

Supplementary Material 3: The weighting method used for two-level regression models

Studies have indicated that it is required to use scaling weights instead of the "raw" weights in multilevel models.⁸⁻¹⁰ Following previous studies,^{8,11} we calculated scaled individual-level weights as below:

$$w_{ij}^* = w_{ij} \left(\frac{n_j}{\sum_i w_{ij}} \right)$$

where w_{ij}^* is the scaled weight for individual i in cluster j , w_{ij} is the unscaled weight for individual i in cluster j , and n_j is the sample size in cluster j . Each county represents one cluster in our study.

Supplementary Table 1. Missing data

	2010	2012	2013	2015
	Total = 11,783	Total = 11,765	Total = 11,438	Total = 10,968
Gender	0	0	0	0
Age	9	4	2	0
Ethnicity	22	9	12	20
Marital status	8	0	23	0
Education	15	4	6	29
Annual household income	758	548	614	348
Number of household member	0	0	0	0
Occupation	80	74	107	218
Frequency of socializing	76	8	4	6
Trust	21	6	14	41
Civic participation	28	11	15	102
Place of residence	0	0	0	0
Physical health	15	4	2	7
Mental health	51	17	21	26

Supplementary Table 2. Unweighted sample characteristics

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	41.71	44.09	35.81	40.12
Good	58.29	55.91	64.19	59.88
Mental Health				
Poor	34.24	34.77	28.79	32.34
Good	65.76	65.23	71.21	67.66
Sociodemographic factors				
Gender				
Female	51.79	48.83	49.85	53.10
Male	48.21	51.17	50.15	46.90
Age (years)	47.50±15.66	49.07±16.22	48.72±16.44	50.61±16.91
Ethnicity				
Non-Han	9.11	8.79	8.59	7.96
Han	90.89	91.21	91.41	92.04
Marital status				
Single/separated/divorced/widowed	19.44	19.92	21.00	21.71
Cohabit/married	80.56	80.08	79.00	78.29
Socioeconomic factors				
Education				
Primary school or below	36.92	37.23	36.18	38.21
Junior secondary school	29.52	28.31	29.04	28.52
Senior secondary school or equal	19.13	18.86	18.88	17.81
College or above	14.44	15.60	15.90	15.46
Occupation				
Skill 3 or 4	10.32	12.81	11.54	9.83
Skill 2	50.12	48.06	47.25	42.61
Skill 1	3.61	2.88	3.48	4.14
Non-employed	35.96	36.25	37.74	43.42
Poverty				
Poor	12.08	16.38	14.67	17.10
Non-poor	81.68	76.31	77.06	77.54
Do not know income	6.24	7.30	8.27	5.36
Place of residence				
Urban	59.64	59.68	59.98	57.82
Rural	40.36	40.32	40.02	42.18
Social capital				
Frequency of socializing				
Low	78.05	74.07	72.29	72.26

High	21.95	25.93	27.71	27.74
Civic participation				
No	53.59	50.93	56.13	52.87
Yes	46.41	49.07	43.87	47.13
Trust				
Low	33.92	35.27	43.62	35.89
High	66.08	64.73	56.38	64.11
Community level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	23.03±10.15	25.92±9.78	26.89±12.58	26.44±11.53
Civic participation (%)	46.12±18.64	47.69±18.32	43.68±18.14	46.49±19.83
Trust (%)	65.36±10.05	64.19±11.70	55.34±13.51	63.54±9.97

Supplementary Table 3. Associations of individual-level and community-level social capital with physical health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” physical health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.50*** (1.30,1.74)	1.38*** (1.20,1.59)	1.19* (1.03,1.38)	1.37*** (1.19,1.57)	1.19** (1.05,1.33)	1.24*** (1.11,1.39)	1.20** (1.06,1.36)	1.25*** (1.10,1.41)
Age	0.96*** (0.95,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.97)	0.97*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.95,0.96)	0.96*** (0.96,0.97)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	1.00 (0.74,1.36)	0.98 (0.75,1.28)	0.80 (0.59,1.07)	1.20 (0.90,1.60)	0.80 (0.61,1.05)	0.99 (0.76,1.29)	1.26 (0.95,1.68)	1.02 (0.77,1.36)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.02 (0.83,1.25)	0.98 (0.81,1.19)	0.96 (0.79,1.17)	1.00 (0.84,1.21)	1.03 (0.89,1.19)	0.87 (0.75,1.01)	1.05 (0.90,1.22)	0.89 (0.76,1.03)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.39*** (1.17,1.64)	1.48*** (1.26,1.74)	1.64*** (1.39,1.95)	1.24* (1.05,1.47)	0.97 (0.83,1.15)	0.92 (0.78,1.08)	0.94 (0.79,1.11)	1.02 (0.86,1.21)

1									
2									
3									
4									
5	Senior secondary school or equal	1.50**	1.53**	1.54**	2.08***	1.15	1.16	1.25*	1.20
6		(1.14,1.96)	(1.18,1.98)	(1.17,2.03)	(1.57,2.75)	(0.97,1.37)	(0.98,1.38)	(1.03,1.51)	(1.00,1.44)
7	College or above	1.61	2.75***	3.18***	1.78*	1.26*	1.23*	1.26*	1.45**
8		(0.85,3.05)	(1.52,4.98)	(1.72,5.89)	(1.09,2.89)	(1.02,1.56)	(1.00,1.50)	(1.01,1.58)	(1.16,1.80)
9									
10	Poverty								
11	Poor	1	1	1	1	1	1	1	1
12	Non-poor	1.70***	1.59***	1.56***	1.61***	1.26	1.71***	1.81***	1.53***
13		(1.42,2.03)	(1.36,1.87)	(1.32,1.85)	(1.37,1.88)	(0.99,1.61)	(1.37,2.13)	(1.44,2.28)	(1.24,1.91)
14	Do not know income	1.59**	1.54**	1.28	1.02	1.25	1.31	1.69***	1.53*
15		(1.14,2.20)	(1.17,2.04)	(0.98,1.69)	(0.74,1.41)	(0.89,1.73)	(0.97,1.77)	(1.25,2.29)	(1.10,2.13)
16									
17	Occupation								
18	Skill level 3 or 4	1	1	1	1	1	1	1	1
19	Skill level 2	0.91	0.89	0.77	1.17	0.89	0.97	1.01	0.98
20		(0.56,1.48)	(0.58,1.36)	(0.48,1.26)	(0.73,1.86)	(0.73,1.09)	(0.81,1.16)	(0.82,1.24)	(0.78,1.22)
21	Skill level 1	1.53	1.23	1.03	1.29	1.04	0.89	0.93	0.73
22		(0.79,2.93)	(0.66,2.30)	(0.53,2.00)	(0.73,2.29)	(0.75,1.45)	(0.64,1.23)	(0.66,1.32)	(0.52,1.03)
23	Non-employed	0.64	0.74	0.49**	1.00	0.65***	0.73***	0.64***	0.70**
24		(0.39,1.05)	(0.48,1.15)	(0.30,0.80)	(0.62,1.60)	(0.53,0.80)	(0.61,0.88)	(0.52,0.80)	(0.56,0.87)
25									
26									
27									
28	Individual-level social capital								
29	Frequency of socializing								
30	Low	1	1	1	1	1	1	1	1
31	High	1.44***	1.49***	1.29**	1.37***	1.51***	1.33***	1.27**	1.34***
32		(1.19,1.75)	(1.26,1.77)	(1.10,1.50)	(1.19,1.59)	(1.31,1.73)	(1.17,1.51)	(1.09,1.47)	(1.15,1.55)
33									
34	Civic participation								
35	No	1	1	1	1	1	1	1	1
36	Yes	1.04	0.99	0.89	0.88	0.97	1.02	1.13	1.10
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									

	(0.89,1.22)	(0.86,1.15)	(0.76,1.04)	(0.76,1.02)	(0.85,1.10)	(0.90,1.15)	(0.98,1.29)	(0.96,1.25)
Trust								
Low	1	1	1	1	1	1	1	1
High	1.24**	1.26**	1.07	1.39***	1.39***	1.32***	1.36***	1.40***
	(1.06,1.45)	(1.09,1.46)	(0.92,1.24)	(1.20,1.61)	(1.23,1.56)	(1.18,1.48)	(1.20,1.54)	(1.24,1.59)
Community-level social capital								
High frequency of socializing (%)	0.99	1.01	1.00	1.01*	0.99	1.00	1.01	1.01**
	(0.97,1.01)	(1.00,1.02)	(0.98,1.01)	(1.00,1.02)	(0.98,1.00)	(0.99,1.01)	(0.99,1.02)	(1.01,1.02)
Civic participation (%)	1.00	1.00	1.00	1.00	1.00	0.99**	0.99**	0.99***
	(0.99,1.01)	(1.00,1.01)	(1.00,1.01)	(0.99,1.00)	(0.99,1.00)	(0.99,1.00)	(0.98,1.00)	(0.99,1.00)
Trust (%)	1.00	1.01	1.01	1.01	1.00	1.01	1.00	1.01
	(0.98,1.02)	(0.99,1.02)	(0.99,1.02)	(1.00,1.03)	(0.99,1.01)	(1.00,1.01)	(0.99,1.01)	(1.00,1.02)
<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
<i>N of communities[#]</i>	89	87	86	87	129	125	121	124

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] One community (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of communities in our study is not equal to the sum of the number of communities in rural samples and the number of communities in urban samples.

Supplementary Table 4. Associations of individual-level and community-level social capital with mental health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” mental health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.41*** (1.22,1.62)	1.48*** (1.29,1.69)	1.11 (0.96,1.29)	1.41*** (1.23,1.63)	1.13* (1.01,1.27)	1.24*** (1.10,1.38)	1.13 (0.99,1.27)	1.16* (1.03,1.31)
Age	0.98*** (0.98,0.99)	0.98*** (0.98,0.99)	0.99*** (0.99,1.00)	0.99*** (0.98,0.99)	0.99** (0.99,1.00)	1.00 (0.99,1.00)	0.99*** (0.98,0.99)	1.00 (0.99,1.00)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	0.88 (0.66,1.18)	0.91 (0.69,1.20)	0.86 (0.64,1.16)	1.00 (0.74,1.34)	0.91 (0.70,1.19)	1.24 (0.96,1.61)	1.18 (0.89,1.56)	1.17 (0.89,1.55)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.16 (0.96,1.40)	1.13 (0.94,1.35)	1.45*** (1.21,1.75)	1.19* (1.00,1.43)	1.28*** (1.11,1.47)	1.21** (1.06,1.39)	1.20* (1.04,1.39)	1.19* (1.03,1.37)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.33*** (1.13,1.57)	1.25** (1.07,1.48)	1.42*** (1.19,1.70)	1.09 (0.92,1.29)	1.30** (1.11,1.53)	1.17 (1.00,1.38)	1.05 (0.88,1.25)	1.42*** (1.20,1.68)

1									
2									
3									
4									
5	Senior secondary school or equal	1.46**	1.39*	1.28	1.48**	1.44***	1.53***	1.30**	1.75***
6		(1.12,1.90)	(1.06,1.82)	(0.97,1.69)	(1.12,1.94)	(1.21,1.71)	(1.29,1.83)	(1.07,1.58)	(1.45,2.11)
7	College or above	1.27	2.15**	3.48***	1.57	1.67***	1.50***	1.30*	1.92***
8		(0.71,2.29)	(1.21,3.85)	(1.97,6.16)	(0.99,2.49)	(1.35,2.06)	(1.23,1.84)	(1.04,1.63)	(1.54,2.40)
9									
10	Poverty								
11	Poor	1	1	1	1	1	1	1	1
12	Non-poor	1.69***	1.61***	1.78***	1.54***	1.76***	1.77***	1.76***	1.40**
13		(1.42,2.00)	(1.38,1.87)	(1.50,2.11)	(1.31,1.80)	(1.40,2.22)	(1.43,2.19)	(1.40,2.20)	(1.14,1.73)
14	Do not know income	2.24***	1.50**	1.27	1.22	1.66**	1.62**	1.42*	1.45*
15		(1.63,3.08)	(1.15,1.96)	(0.98,1.65)	(0.89,1.67)	(1.21,2.27)	(1.21,2.16)	(1.06,1.91)	(1.06,1.99)
16									
17	Occupation								
18	Skill level 3 or 4	1	1	1	1	1	1	1	1
19	Skill level 2	0.73	0.91	1.00	1.28	1.04	0.98	0.96	1.15
20		(0.45,1.18)	(0.59,1.43)	(0.62,1.61)	(0.81,2.01)	(0.86,1.26)	(0.82,1.17)	(0.79,1.17)	(0.93,1.42)
21	Skill level 1	0.65	0.61	0.95	1.22	1.34	1.16	1.04	1.02
22		(0.35,1.21)	(0.32,1.13)	(0.49,1.82)	(0.70,2.15)	(0.96,1.87)	(0.83,1.62)	(0.74,1.47)	(0.73,1.44)
23	Non-employed	0.58*	0.85	0.70	1.05	1.00	1.01	0.99	1.01
24		(0.36,0.95)	(0.54,1.34)	(0.43,1.15)	(0.66,1.65)	(0.82,1.22)	(0.85,1.22)	(0.80,1.21)	(0.81,1.25)
25									
26									
27									
28	Individual-level social capital								
29	Frequency of socializing								
30	Low	1	1	1	1	1	1	1	1
31	High	1.10	1.24*	1.36***	1.54***	1.33***	1.17*	1.23**	1.18*
32		(0.92,1.33)	(1.05,1.47)	(1.17,1.59)	(1.33,1.79)	(1.16,1.53)	(1.03,1.33)	(1.06,1.43)	(1.02,1.37)
33									
34	Civic participation								
35	No	1	1	1	1	1	1	1	1
36	Yes	0.90	1.00	1.04	0.89	1.03	1.06	1.29***	1.16*
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									

1									
2									
3									
4									
5		(0.77,1.04)	(0.86,1.15)	(0.89,1.21)	(0.76,1.03)	(0.91,1.17)	(0.93,1.19)	(1.13,1.49)	(1.01,1.33)
6	Trust								
7	Low	1	1	1	1	1	1	1	1
8	High	1.43***	1.36***	1.22**	1.58***	1.47***	1.48***	1.48***	1.32***
9		(1.23,1.66)	(1.18,1.57)	(1.05,1.41)	(1.37,1.83)	(1.31,1.65)	(1.32,1.66)	(1.31,1.67)	(1.17,1.49)
10	Community-level social capital								
11	Frequency of socializing (%)	1.00	1.01	1.00	1.02**	1.00	1.00	1.00	1.00
12		(0.98,1.01)	(0.99,1.02)	(0.98,1.01)	(1.00,1.03)	(0.99,1.01)	(0.99,1.02)	(0.99,1.01)	(0.99,1.01)
13	Civic participation (%)	1.00	1.01	1.00	1.00	1.00	1.00	0.99	1.00
14		(1.00,1.01)	(1.00,1.02)	(0.99,1.01)	(0.99,1.01)	(0.99,1.00)	(0.99,1.01)	(0.98,1.00)	(0.99,1.00)
15	Trust (%)	0.99	1.01	1.00	1.00	1.00	1.01	0.99	1.01
16		(0.98,1.01)	(0.99,1.02)	(0.99,1.02)	(0.99,1.02)	(0.99,1.01)	(1.00,1.02)	(0.98,1.00)	(1.00,1.02)
17	<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
18	<i>N of communities[#]</i>	89	87	86	87	129	125	121	124

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] One community (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of communities in our study is not equal to the sum of the number of communities in rural samples and the number of communities in urban samples.

Supplementary Table 5. Associations of individual-level and community-level social capital, and national GDP with physical health and mental health, pooled data from 2010-2015 (Multi-level binary logistic model, with “poor” physical health and “poor” mental health as references)

	Two-level models without GDP		Three-level models with GDP	
	Physical health Adjusted OR (95% CI)	Mental health Adjusted OR (95% CI)	Physical health Adjusted OR (95% CI)	Mental health Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.28*** (1.22,1.34)	1.23*** (1.17,1.28)	1.28*** (1.23,1.34)	1.23*** (1.18,1.29)
Age	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)
Ethnicity				
Non-Han	1	1	1	1
Han	0.98 (0.88,1.09)	0.95 (0.86,1.05)	0.98 (0.89,1.09)	0.96 (0.87,1.06)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	0.95 (0.90,1.01)	1.23*** (1.17,1.30)	0.96 (0.91,1.02)	1.24*** (1.17,1.31)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.18*** (1.12,1.25)	1.27*** (1.20,1.34)	1.19*** (1.12,1.26)	1.27*** (1.20,1.35)
Senior secondary school or equal	1.38*** (1.29,1.48)	1.47*** (1.37,1.58)	1.39*** (1.30,1.49)	1.48*** (1.38,1.59)
College or above	1.48*** (1.35,1.62)	1.53*** (1.40,1.67)	1.52*** (1.39,1.67)	1.56*** (1.43,1.71)
Poverty				
Poor	1	1	1	1
Non-poor	1.61*** (1.51,1.71)	1.67*** (1.57,1.78)	1.62*** (1.51,1.73)	1.71*** (1.61,1.82)
Do not know income	1.41*** (1.27,1.56)	1.50*** (1.37,1.66)	1.44*** (1.30,1.60)	1.51*** (1.36,1.66)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.94 (0.86,1.03)	1.08 (0.99,1.17)	0.94 (0.86,1.02)	1.06 (0.97,1.16)
Skill level 1	1.02 (0.88,1.17)	1.08 (0.94,1.24)	1.01 (0.87,1.16)	1.08 (0.94,1.24)
Non-employed	0.71***	0.99	0.71***	0.99

1					
2					
3		(0.65,0.78)	(0.91,1.08)	(0.64,0.77)	(0.90,1.08)
4	Place of residence				
5	Rural	1	1	1	1
6	Urban	1.18***	1.05	1.19***	1.07*
7		(1.11,1.25)	(1.00,1.11)	(1.12,1.26)	(1.01,1.14)
8					
9	Individual-level social capital				
10	Frequency of socializing				
11	Low	1	1	1	1
12	High	1.37***	1.28***	1.37***	1.28***
13		(1.30,1.44)	(1.22,1.35)	(1.30,1.44)	(1.22,1.35)
14	Civic participation				
15	No	1	1	1	1
16	Yes	1.00	1.05	1.00	1.05*
17		(0.96,1.05)	(1.00,1.10)	(0.96,1.05)	(1.00,1.10)
18	Trust				
19	Low	1	1	1	1
20	High	1.30***	1.41***	1.31***	1.42***
21		(1.24,1.36)	(1.35,1.47)	(1.25,1.37)	(1.36,1.49)
22	Community-level social capital				
23	Frequency of socializing (%)	1.00	1.00*	1.00	1.00
24		(1.00,1.00)	(1.00,1.01)	(1.00,1.01)	(1.00,1.01)
25	Civic participation (%)	0.99***	1.00**	1.00**	1.00
26		(0.99,0.99)	(0.99,1.00)	(0.99,1.00)	(1.00,1.00)
27	Trust (%)	1.00**	1.00	1.01**	1.00
28		(0.99,1.00)	(1.00,1.00)	(1.00,1.01)	(1.00,1.00)
29	Year				
30	National GDP (trillion yuan)	NA	NA	1.01	1.01
31				(1.00,1.03)	(1.00,1.02)
32	<i>N of individuals</i>	42,829	42,829	42,829	42,829
33	<i>N of communities</i>	520	520	520	520
34	<i>N of years</i>	4	4	4	4

* p < 0.05, ** p < 0.01, *** p < 0.001

1 trillion yuan ≈ 141 billion US\$

Supplementary Table 6. Interactions between consistently significant social capital indicators and survey year, pooled data from 2010-2015 (Two-level binary logistic model, with “poor” physical health and “poor” mental health as references)

	Physical health Adjusted OR (95% CI)	Mental health Adjusted OR (95% CI)
Interaction term		
Individual-level high frequency of social intercourse	1.00	1.02
× Year	(0.97,1.03)	(1.00,1.05)
Individual-level high trust × Year	1.01	1.00
	(0.98,1.03)	(0.97,1.02)
<i>N of individuals</i>	42,829	42,829

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Year and all other variables in Table 2 and Table 3 are adjusted.

Supplementary Table 7. Associations of individual-level and community-level social capital with physical health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24**	1.37***	1.15*	1.29***
	(1.08,1.43)	(1.22,1.54)	(1.02,1.29)	(1.14,1.47)
Age				
	0.96***	0.96***	0.96***	0.96***
	(0.95,0.96)	(0.95,0.96)	(0.96,0.97)	(0.96,0.96)
Ethnicity				
Non-Han	1	1	1	1
Han	0.85	0.90	0.90	1.02
	(0.72,1.00)	(0.71,1.13)	(0.65,1.25)	(0.79,1.31)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	0.91	0.96	1.10	0.93
	(0.80,1.04)	(0.79,1.17)	(0.92,1.32)	(0.80,1.07)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.33***	1.25**	1.48***	1.30**
	(1.16,1.53)	(1.09,1.44)	(1.23,1.80)	(1.10,1.54)
Senior secondary school or equal	1.41***	1.55***	1.76***	1.66***
	(1.18,1.67)	(1.31,1.83)	(1.44,2.15)	(1.39,1.99)
College or above	1.63***	1.64***	2.08***	1.91***
	(1.31,2.03)	(1.28,2.09)	(1.63,2.65)	(1.52,2.41)
Poverty				
Poor	1	1	1	1
Non-poor	1.66***	1.52***	1.58***	1.59***
	(1.40,1.98)	(1.29,1.79)	(1.32,1.88)	(1.34,1.88)
Do not know income	1.61***	1.55***	1.55***	1.25
	(1.25,2.07)	(1.23,1.96)	(1.22,1.97)	(0.92,1.70)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.87	0.82	0.80	1.02
	(0.70,1.08)	(0.64,1.07)	(0.63,1.00)	(0.81,1.30)
Skill level 1	1.37	0.79	0.99	1.01
	(0.94,2.00)	(0.53,1.16)	(0.73,1.33)	(0.71,1.43)
Non-employed	0.70**	0.74**	0.62***	0.88
	(0.55,0.88)	(0.59,0.92)	(0.50,0.76)	(0.69,1.12)

Place of residence				
Rural	1	1	1	1
Urban	1.01	1.09	1.15	1.19*
	(0.86,1.20)	(0.96,1.23)	(0.99,1.34)	(1.02,1.38)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.47***	1.40***	1.18*	1.27**
	(1.28,1.69)	(1.24,1.59)	(1.04,1.34)	(1.08,1.48)
Civic participation				
No	1	1	1	1
Yes	0.96	1.10	0.96	0.97
	(0.84,1.10)	(0.97,1.25)	(0.84,1.09)	(0.85,1.10)
Trust [#]				
Low	1	1	1	1
High	1.36***	1.32***	1.13	1.45***
	(1.21,1.52)	(1.17,1.48)	(0.99,1.30)	(1.27,1.65)
Community-level social capital				
Frequency of socializing (%)	0.99	1.01	1.00	1.02***
	(0.98,1.00)	(1.00,1.02)	(0.99,1.01)	(1.01,1.03)
Civic participation (%)	1.00	1.00	1.00	1.00
	(0.99,1.01)	(0.99,1.01)	(0.99,1.01)	(0.99,1.00)
Trust (%)	1.00	1.01	1.01	1.01
	(0.98,1.01)	(1.00,1.02)	(1.00,1.02)	(1.00,1.02)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] p = 0.063 in 2013

Supplementary Table 8. Associations of individual-level and community-level social capital with mental health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.22**	1.47***	1.03	1.29***
	(1.08,1.37)	(1.33,1.64)	(0.91,1.18)	(1.15,1.45)
Age				
	0.98***	0.98***	0.99***	0.99***
	(0.98,0.99)	(0.98,0.99)	(0.98,0.99)	(0.99,1.00)
Ethnicity				
Non-Han	1	1	1	1
Han	0.79*	0.97	0.93	0.94
	(0.64,0.96)	(0.78,1.21)	(0.67,1.28)	(0.75,1.18)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.23**	1.16	1.46***	1.32***
	(1.05,1.43)	(0.99,1.35)	(1.24,1.73)	(1.12,1.54)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.34***	1.23**	1.42***	1.33***
	(1.18,1.53)	(1.05,1.43)	(1.17,1.73)	(1.14,1.56)
Senior secondary school or equal	1.34**	1.62***	1.58**	1.68***
	(1.12,1.60)	(1.33,1.96)	(1.16,2.16)	(1.36,2.06)
College or above	1.43**	1.46***	2.04***	1.93***
	(1.12,1.82)	(1.18,1.82)	(1.48,2.81)	(1.52,2.46)
Poverty				
Poor	1	1	1	1
Non-poor	1.71***	1.58***	1.65***	1.55***
	(1.47,2.00)	(1.38,1.82)	(1.41,1.95)	(1.33,1.81)
Do not know income	1.95***	1.42**	1.32*	1.46**
	(1.49,2.54)	(1.12,1.82)	(1.05,1.65)	(1.10,1.95)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.98	0.90	1.17	1.30*
	(0.77,1.24)	(0.71,1.13)	(0.87,1.56)	(1.01,1.67)
Skill level 1	0.94	0.67*	1.29	1.51
	(0.66,1.35)	(0.47,0.94)	(0.81,2.04)	(0.96,2.37)
Non-employed	0.94	0.97	1.11	1.18
	(0.74,1.19)	(0.77,1.22)	(0.81,1.51)	(0.91,1.53)

Place of residence				
Rural	1	1	1	1
Urban	1.04	0.93	0.97	1.06
	(0.90,1.19)	(0.80,1.08)	(0.84,1.12)	(0.92,1.22)
Individual-level social capital				
Frequency of socializing [#]				
Low	1	1	1	1
High	1.18	1.13	1.29***	1.36***
	(0.98,1.42)	(0.99,1.29)	(1.14,1.46)	(1.17,1.59)
Civic participation				
No	1	1	1	1
Yes	0.96	0.95	1.10	0.94
	(0.86,1.08)	(0.84,1.08)	(0.95,1.28)	(0.82,1.08)
Trust				
Low	1	1	1	1
High	1.42***	1.39***	1.26***	1.33***
	(1.28,1.59)	(1.24,1.56)	(1.10,1.45)	(1.20,1.48)
Community-level social capital				
Frequency of socializing (%)	0.99	1.01*	1.00	1.01*
	(0.98,1.01)	(1.00,1.02)	(0.99,1.01)	(1.00,1.02)
Civic participation (%)	1.00	1.01	1.00	1.00
	(1.00,1.01)	(1.00,1.01)	(0.99,1.01)	(0.99,1.00)
Trust (%)	0.99	1.01	1.00	1.00
	(0.98,1.00)	(1.00,1.02)	(0.99,1.01)	(0.99,1.02)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

p = 0.080 in 2010, p = 0.070 in 2012

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Are Both Individual-level and Community-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

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Are Both Individual-level and Community-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

ABSTRACT

Objectives We aimed to examine the associations of both individual-level and community-level social capital with individual health in China during a period of rapid economic growth.

Design and setting: A serial cross-sectional study in China.

Participants and methods The participants were 42,829 Chinese adults (age ≥ 18 years) from the 2010, 2012, 2013, and 2015 Chinese General Social Survey. The outcomes were self-rated physical and mental health in all time points. We assessed social capital by individual-level and community-level indicators, including frequency of socializing, civic participation, and trust. We conducted multilevel binary logistic regression models to examine the associations of individual-level and community-level social capital with self-rated physical and mental health.

Results At the individual level, high frequency of socializing (2010: OR 1.49, 95%CI 1.33 to 1.66; 2012: OR 1.39, 95%CI 1.26 to 1.54; 2013: OR 1.28, 95%CI 1.15 to 1.42; 2015: 1.36, 95%CI 1.23 to 1.50) and high trust (2010: OR 1.34, 95%CI 1.22 to 1.47; 2012: OR 1.30, 95%CI 1.18 to 1.42; 2013: OR 1.21, 95%CI 1.10 to 1.33; 2015: OR 1.41, 95%CI 1.28 to 1.55) were significantly associated with good physical health in all years. At the individual level, high frequency of socializing (2010: OR 1.27, 95%CI 1.14 to 1.42; 2012: OR 1.21, 95%CI 1.09 to 1.34; 2013: OR 1.30, 95%CI 1.17 to 1.45; 2015: 1.35, 95%CI 1.22 to 1.50) and high trust (2010: OR 1.47, 95%CI 1.34 to 1.61; 2012: OR 1.42, 95%CI 1.30 to 1.56; 2013: OR 1.36, 95%CI 1.24 to 1.49; 2015: OR 1.43, 95%CI 1.30 to 1.57) were also significantly associated with good mental health in all years. No evidence showed that the associations of individual-level frequency of socializing and trust with physical and mental health changed over time. There were no consistent associations of individual-level civic participation or any community-level social capital indicators with physical or mental health.

Conclusion The positive associations of individual-level social capital in terms of socializing and trust with physical and mental health were robust during a period of rapid economic growth. Improving individual-level socializing and trust for health promotion could be a long-term strategy even within a rapidly developing society.

Strengths and limitations of this study

- A major strength of our study is the comparability of the associations between multilevel social capital and health outcomes over time. Hence, our consistent findings provided more solid evidence for associations of the individual-level frequency of socializing and trust with physical and mental health beyond previous mixed results.
- The other strength of our study is that we took advantage of a rapidly developing society (i.e., China) as a social laboratory to observe the associations between multilevel social capital and health outcomes.
- A limitation of our study is that we cannot make causal inferences since this study is cross-sectional by nature.
- We only included generalized trust in cognitive social capital.
- The study period was relatively short (i.e., six years), which prohibited us from observing a more long-term trend of the association.

INTRODUCTION

Social capital, defined as resources available to members of social groups and resources embedded within an individual's social networks,^{1,2} is a critical social determinant in shaping population health. Although debates are ongoing as to whether social capital is an individual attribute or a collective property, previous public health studies suggested that the individual and collective perspectives were not mutually exclusive and might affect individuals' health simultaneously.^{3,4} From an individual perspective, social capital affects health by providing informational, emotional, and instrumental support. From a collective perspective, social capital affects health by facilitating collective action, maintaining social norms, and enhancing reciprocity.^{5,6}

An increasing number of studies employed a multilevel analytical framework to examine the associations of both individual-level and collective-level social capital with health. Nevertheless, results from these multilevel studies were mixed.^{3,7-10} Most of these studies found that at least one indicator of each level of social capital was associated with health. Some studies only showed an association between individual-level social capital and health, while a handful of studies suggested that only collective-level social capital was associated with health. Although most of these studies indicated that social capital was beneficial for health, several studies reported negative associations between higher levels of social capital and better health.¹¹⁻¹³ Even studies within the same countries (e.g., Japan^{12,14} and China^{13,15}) showed inconsistent results in terms of the directions of the associations between social capital and health.

The above-mentioned inconsistent results may be due to different operationalizations of social capital, different study time points, or both. Although different operationalizations of social capital provided insights to understand what specific social capital indicator was beneficial for health among a spectrum of social capital measures, they made it difficult to make meaningful comparisons between studies and to examine whether the association between social capital and health was consistent over time. A Chinese study indicated that the association between individual-level social capital and health varied with periods.¹⁶ A newly published study in Montreal, Canada also only examined the association of individual-level social capital with health over time.¹⁷ Additionally, as Montreal is only a representative of developed society, the results may not be applicable in a rapidly developing society.

It is important to understand whether the association of social capital with health is robust over time. If the association is consistent over time, improving social capital could be considered a long-term health promotion strategy. However, the question is understudied, and the answer to this question is theoretically debatable, especially with rapid economic growth.

On one hand, it is argued that economic growth may erode social capital as it can extend market relationships to people's noneconomic life.¹⁸ With economic growth, the time available for people's social activities may also reduce, leading to a decrease in social capital. As found in the United States, social capital decreased continuously despite the growing economy.¹⁹ Hence, it is postulated in this theory that people's health may depend less on social capital as economy grows, and they can receive health benefits directly from economic growth. In other words, the strength of the association between social capital and health may decline as economy grows.

On the other hand, it is also argued that social capital may still be important for people's health during rapid economic development. Rapid economic growth often co-exists with social change; thus, formal institutions may not be well established in a rapidly developing society, and people may need to rely on informal institutions, which has significant overlaps with social capital.²⁰ Also, social change may lead to social uncertainties; in other words, social capital is important for obtaining information and support from others to address these uncertainties.²¹ For instance, a Chinese study found that social capital could reduce suicide ideation by reducing uncertainty stress.²²

To understand whether the association of social capital with health changed during a period with rapid economic growth, we examined the associations of both individual-level and community-level social capital with health

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3 over time in China. China is an ideal setting for this study since it has experienced rapid economic development
4 over the past four decades. Its gross domestic product (GDP) increased rapidly from 1.8% of the global economy
5 in 1978 to 15% in 2018.²³ This rapid economic transition allows us to use a relatively short period to observe
6 whether the association between multilevel social capital and health changed with socioeconomic development.
7 It also allows us to compare the difference in the change of association of multilevel social capital with health
8 between the traditionally long-term developed western societies and those with more recent and rapid economic
9 development. Additionally, China is also characterized by its traditional culture of relationship traceable back to
10 Confucian ethics.²⁴ Collectivistic culture in China institutionalizes the legitimacy of individuals' dependence on
11 social networks.²⁵ This distinction of the Chinese culture from other western societies, where individualistic
12 culture facilitates independence from each other,²⁶ may give us further insights into the association between social
13 capital and health that may be overlooked previously.

14 We specifically examined: (1) how individual-level social capital, community-level social capital, and health
15 changed during a period of rapid economic growth; (2) what the associations of individual-level and community-
16 level social capital with health were in each survey year; (3) whether the associations changed during a period of
17 rapid economic growth.

23 METHODS

24 Data source and participants

25 We collected data from the 2010, 2012, 2013, and 2015 waves of the Chinese General Social Survey (CGSS),
26 which is publicly available. The participants were Chinese adults aged 18 years or above. Health outcomes, social
27 capital, sociodemographic, and socioeconomic factors were consistently collected throughout the four years. The
28 CGSS is a national representative survey project in Mainland China conducted by the Renmin University of China.
29 The sampling strategy was described in further details in a previous study.¹³

30 Measurements

31 Health outcomes

32 Health outcomes were self-rated physical and mental health. For physical health, respondents answered the
33 question "How do you think about your current physical health?" Responses were divided into "poor" (including
34 "very unhealthy", "unhealthy", and "neutral") and "good" (including "healthy" and "very healthy") physical
35 health. For mental health, respondents answered the question "During the past four weeks, how often have you
36 felt depressed or downhearted?" This question is taken from the 12-item Short-Form Health Survey.²⁷ Responses
37 were categorized into "poor" (including "always", "often", and "sometimes") and "good" (including "seldom"
38 and "never") mental health. The two self-rated health indicators were used in previous studies.²⁸⁻³⁰

39 Social capital

40 Social capital can be separated into structural and cognitive dimensions. Structural social capital refers to actual
41 network connections and civic engagement while cognitive social capital refers to perceptions of trust and norms.³
42 We measured individual-level structural social capital by respondents' frequency of socializing (high, low) and
43 civic participation (yes, no). We measured individual-level cognitive social capital by respondents' trust of others
44 (high, low). Details of the questions are shown in Supplementary Material 1.

45 We calculated community-level social capital by using individual-level social capital variables. Community,
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3 by definition, is a group of people who interact with one another within a geographic territory, such as a
4 neighborhood or city.³¹ In this study, we treated each county-level administrative unit (hereafter referred to as
5 “county”) as a community. Counties are the primary sampling units in CGSS.¹³ On average, each county included
6 81 respondents in 2010, 85 in 2012, 85 in 2013, and 79 in 2015. Following previous studies,^{32–34} we conducted
7 two-level random intercept logistic regressions to calculate community-level social capital, with individuals as
8 Level 1 and counties as Level 2. We treated each variable of the three above-mentioned individual-level social
9 capital indicators as dependent variables. We calculated community-level social capital by adding the grand mean
10 of county social capital to the residuals at the county level. Details are shown in Supplementary Material 2. Higher
11 percentages indicated higher community-level social capital.
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17 Sociodemographic and socioeconomic factors

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19 We included gender (male, female), age (years), ethnicity (*Han*, non-*Han*), and marital status
20 (married/cohabitation, never married/divorced/separated/widowed) as sociodemographic factors, and education
21 (primary school or below, junior secondary school, senior secondary school, and college or above), occupation,
22 poverty, and places of residence (rural, urban) as socioeconomic factors. There are 56 ethnic groups in China and
23 *Han* is the majority. The heterogeneity across ethnic groups in terms of socio-economic experience and culture
24 may affect both people’s health and social capital.³⁵ Thus, we controlled for ethnicity in our study. Details of the
25 occupation and poverty are shown in Supplementary Material 3.
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29 Statistical analysis

30 We reported weighted means with standard deviations (SD) for continuous variables and weighted percentages
31 for categorical variables. We calculated individual weighting factors by the distribution of gender, age, and place
32 of residence according to the 2010 China population census data,³⁶ and community weighting factors according
33 to the distribution of the numbers of counties in each province in 2010 based on the China Statistical Yearbook
34 2011.³⁷ To examine how social capital and health changed over time, following the methodology as in previous
35 studies,^{38,39} we assessed the trends of health and individual-level social capital by conducting binary logistic
36 regression models with the calendar year as the independent variable. The results of the regressions indicated
37 whether the health variations and the individual-level social capital variations between years were statistically
38 significant. Similarly, with the calendar year as the independent variable, we assessed the trends of community-
39 level social capital by linear regression models. Years were treated as fixed effects in the above-mentioned models.
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44 To examine the associations of individual-level and community-level social capital with health, we employed
45 two-level binary logistic regression models adjusting for sociodemographic and socioeconomic factors. The two
46 levels specified in our model were: individuals at Level 1 nested within communities at Level 2. The intercepts at
47 the community level were treated as random. We compared the results of regression models with weighted and
48 unweighted data as a robustness check. The weighting method is shown in Supplementary Material 4. We also
49 treated physical and mental health as ordinal variables and conducted two-level ordinal regression models as a
50 robustness check. To examine whether the associations of social capital with physical and mental health changed
51 over time, we performed interaction tests between social capital indicators and survey year. Following previous
52 literature^{40,41}, we tested the significance of interaction terms by adding each interaction term, one at a time, to the
53 full models.
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56 We used Stata/MP 14.2 to conduct all data analysis with a two-tailed *p*-value < 0.05 as the significance level.
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59 Patient and public involvement

All data in this study were derived from the CGSS dataset. No patients and the public were involved in the design or planning of this study.

RESULTS

Our study included a total of 42,829 respondents. Specifically, there were 10,827 respondents nested in 133 counties in 2010, 11,104 in 131 counties in 2012, 10,663 in 126 counties in 2013, and 10,235 in 130 counties in 2015. Table 1 presents the weighted sample characteristics in 2010, 2012, 2013, and 2015 (The missing data values are listed in online supplementary table 1. The unweighted results are shown in online supplementary table 2). Generally, the percentages of good physical and mental health fluctuated over the study period, but both the percentages were lowest in 2012 and peaked in 2013. For individual-level social capital, high frequency of socializing increased generally and peaked in 2013; civic participation peaked in 2012 and reached the lowest level in 2013; high trust decreased to the bottom in 2013 and then slightly rebounded in 2015. For community-level social capital, the percentage of high frequency of socializing increased; the percentage of civic participation decreased and dropped to the bottom in 2013; the percentage of trust decreased from 2010 to 2013 and then increased in 2015.

[Table 1 here]

Figure 1 shows the trends of physical and mental health, individual-level social capital, and community-level social capital over time. Figure 1a indicates that the likelihood of good physical health in 2012 (odds ratio (OR) 0.95, 95% confidence interval (CI) 0.89–1.00) was marginally significantly ($p = 0.062$) lower than that in 2010 (reference). However, this likelihood in 2013 (OR 1.31, 95% CI 1.24–1.40) and 2015 (OR 1.21, 95%CI 1.13–1.28) was significantly higher than that in 2010. The likelihood of good mental health in 2013 (OR 1.30, 95%CI 1.22–1.38) and 2015 (OR 1.13, 95%CI 1.06–1.21) were also significantly higher than that in 2010. No significant difference in mental health was observed between 2010 and 2012.

Figure 1b shows that the likelihood of high frequency of socializing in 2012 (OR 1.28, 95%CI 1.19–1.37), 2013 (OR 1.34, 95%CI 1.25–1.43), and 2015 (OR 1.31, 95%CI 1.22–1.41) were significantly higher than that in 2010. The likelihood of civic participation in 2012 (OR 1.07, 95%CI 1.01–1.14) was significantly higher than that in 2010. However, it decreased and became significantly lower in 2013 (OR 0.90, 95%CI 0.84–0.95) than that in 2010. No evidence showed that the likelihood of civic participation in 2015 was significantly different from that in 2010. The likelihood of high trust in 2012 (OR 0.92, 95%CI 0.87–0.98), 2013 (OR 0.67, 95%CI 0.63–0.71), and 2015 (OR 0.90, 95%CI 0.84–0.96) was significantly lower than that in 2010.

Figure 1c shows that community-level frequency of socializing in 2012 ($\beta = 12.91$, 95%CI 10.52–15.29), 2013 ($\beta = 16.28$, 95%CI 13.76–18.79), and 2015 ($\beta = 21.30$, 95%CI 18.95–23.66) were significantly higher than that

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4 in 2010. Community-level civic participation in 2012 ($\beta = -3.59$, 95%CI -6.92– -0.26), 2013 ($\beta = -6.87$, 95%CI -
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6 10.21– -3.53), and 2015 ($\beta = -3.59$, 95%CI -7.00– -0.17) were significantly lower than that in 2010. Community-
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8 level trust in 2013 ($\beta = -4.32$, 95%CI -6.72– -1.93) and 2015 ($\beta = -3.32$, 95%CI -5.21– -1.44) were significantly
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10 lower than that in 2010. No evidence showed that community-level trust in 2012 was significantly different from
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12 that in 2010.
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15 *[Figure 1 here]*
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18 Table 2 shows the associations of both individual-level and community-level social capital with physical health.
19 Among the individual-level social capital indicators, high frequency of socializing (2010: OR 1.49, 95%CI 1.33–
20 1.66; 2012: OR 1.39, 95%CI 1.26–1.54; 2013: OR 1.28, 95%CI 1.15–1.42; 2015: 1.36, 95%CI 1.23–1.50) and
21 high trust (2010: OR 1.34, 95%CI 1.22–1.47; 2012: OR 1.30, 95%CI 1.18–1.42; 2013: OR 1.21, 95%CI 1.10–
22 1.33; 2015: OR 1.41, 95%CI 1.28–1.55) were significantly associated with good physical health in all years. No
23 evidence supported that there was a significant association between civic participation and physical health after
24 adjustment in any year. Among community-level social capital indicators, after adjustment, higher percentages of
25 frequency of socializing was significantly positively associated with good physical health in 2015 (socializing:
26 OR 1.01, 95%CI 1.00–1.02). In contrast, a higher percentage of civic participation was significantly negatively
27 associated with good physical health in 2015 (OR 0.99, 95%CI 0.98–1.00); nevertheless, the ORs were close to
28 one.
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33 *[Table 2 here]*
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36 Table 3 presents the associations of both individual-level and community-level social capital with mental health.
37 The associations were similar to that of social capital with physical health in terms of directions and significance.
38 Among individual-level social capital indicators, high frequency of socializing (2010: OR 1.27, 95%CI 1.14–
39 1.42; 2012: OR 1.21, 95%CI 1.09–1.34; 2013: OR 1.30, 95%CI 1.17–1.45; 2015: 1.35, 95%CI 1.22–1.50) and
40 high trust (2010: OR 1.47, 95%CI 1.34–1.61; 2012: OR 1.42, 95%CI 1.30–1.56; 2013: OR 1.36, 95%CI 1.24–
41 1.49; 2015: OR 1.43, 95%CI 1.30–1.57) were significantly associated with good mental health. Civic participation
42 was only positively associated with good mental health in 2013 (OR 1.17, 95%CI 1.05–1.29). No significant
43 association between any community-level social capital indicator and mental health in the four years was observed.
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45 The intraclass correlations (ICCs) ranged from 0.052 to 0.107 for physical health (Table 2) and ranged from
46 0.060 to 0.125 for mental health (Table 3) in each year; in other words, 5.2% to 10.7% of the total variance in
47 physical health and 6.0% to 12.5% of the total variance in mental health occurred at the community level.
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51 *[Table 3 here]*
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54 As for sociodemographic and socioeconomic factors, being male sex, non-poor, and having a higher education
55 level were significantly associated with good physical and mental health in all years. Being older was negatively
56 associated with good physical and mental health in all years. Additionally, being non-employed was significantly
57 associated with a lower likelihood of having good physical health comparing with having occupations at Skill
58 level 3 or 4 (reference) in all years, but not significantly associated with mental health. Being married or cohabiting
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was significantly associated with good mental health in all years, but not associated with physical health.

The results stratified by place of residence (i.e., rural and urban) showed similar patterns to the results from the whole sample in each year in terms of the associations of individual-level frequency of socializing and trust with physical and mental health (online supplementary table 3 and 4). The results from the pooled data between 2010 and 2015 also showed that individual-level social capital in terms of frequency of socializing and trust was associated with physical and mental health after adjustment (online supplementary table 5).

We further examined the interactions between social capital indicators and survey year (online supplementary table 6 and table 7). For physical health, only the interaction effect between community-level frequency of socializing and year (High frequency of socializing \times 2015: OR 1.02, 95%CI 1.01-1.03), and the interaction effect between community-level civic participation and year (Civic participation (Yes) \times 2012: OR 0.99, 95%CI 0.99-1.00) were significant. For mental health, only the interaction effect between community-level frequency of socializing and year (High frequency of socializing \times 2015: OR 1.02, 95%CI 1.01-1.03), the interaction effect between community-level civic participation and year (Civic participation (Yes) \times 2013: OR 0.99, 95%CI 0.99-1.00), and the interaction effect between community-level trust and year (High trust \times 2012: OR 1.01, 95%CI 1.01-1.02; High trust \times 2013: OR 1.01, 95%CI 1.00-1.02). Nevertheless, the ORs were close to one, meaning that they were only marginally significant.

We repeated the two-level binary regression models based on the whole weighted sample of each year (i.e., Table 2 and Table 3). The associations between both levels of social capital and health outcomes (online supplementary table 8 and 9) were similar to our unweighted results in Table 2 and Table 3. We also conducted sensitivity analyses by treating physical and mental health as ordinal variables. The associations between both levels of social capital and health outcomes (online supplementary table 10 and 11) were consistent with our previous results as presented in Table 2 and Table 3.

DISCUSSION

Main findings

To our knowledge, this is the first serial cross-sectional study in China examining the associations of multilevel social capital with individuals' physical and mental health with nationally representative data. We found that the likelihood of having good physical and mental health fluctuated during a period of rapid economic development; in other words, the likelihood of having good physical and mental health did not consistently increase with economic growth during this study period. Among the indicators of individual-level social capital, in general, the likelihood of high frequency of social socializing increased, the likelihood of civic participation fluctuated, and the likelihood of high trust decreased during the survey period. Among the indicators of community-level social capital, in general, the percentage of high frequency of socializing increased, the percentage of civic participation and the percentage of high trust decreased. We also found that higher levels of individual-level social capital in terms of frequency of socializing and trust were consistently associated with good physical and mental health during the period of rapid economic development. However, we did not find evidence for a consistent association of any community-level social capital indicator with physical or mental health during the same period.

Interpretations

Putting all the results together, our study suggests that no matter how people's physical and mental health changed during a period of rapid economic growth, individual-level social capital in terms of socializing and trust consistently played a pivotal role in protecting individuals' physical and mental health. Under such circumstances, the decreased trend in individual-level trust within the observed period indicated that we should especially pay attention to improve people's trust for health promotion.

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3 The provision of informational, instrumental, and emotional support may be plausible reasons why the
4 individual-level frequency of socializing was associated with our health outcomes.^{6,42} Socializing helps maintain
5 and extend individuals' social networks, from which individuals can obtain monetary, material and mental
6 assistance, and health-rated information. Additionally, a higher frequency of socializing is beneficial for mental
7 health by fulfilling the human need for social connectedness, increasing people's sense of belonging, and reducing
8 the perceived isolation.⁴³ Moreover, people with high trust are more likely to consider healthcare systems and
9 health-related information as trustful social resources,^{44,45} and more likely to perceive emotional support.⁴⁶ They
10 also have less sense of social anxiety.⁴⁷

11 We argue that some of the mechanisms above are unchanged in a rapidly developing society, resulting in the
12 observed consistent associations of individual-level socializing and trust with physical and mental health. First, a
13 rapidly developing economy is almost always accompanied by social change. Under such circumstances, the old
14 formal health-related institutions and information channels may not fulfill people's needs while the new ones may
15 not be completely established or may not operate stably. Hence, people need to obtain support from informal
16 channels, such as family members, friends, and acquaintances. Second, a rapidly developing society is often
17 accompanied by technological innovation and information explosion. An individual is almost unlikely to know
18 all about new health-related technology and information on his or her own. In this light, socializing could reduce
19 individuals' costs to learn new health-related technology and obtain new information through social networks.
20 Also, people with a high trust may be more likely to consider emerging health-related institutions, technology,
21 and information in a rapidly developing society as trustworthy, and are thus more willing to use them. An example
22 is online prescription drug services. A study in the United States found that people with higher trust had a higher
23 intention of adopting online prescription drug services.⁴⁸ However, more study is needed to examine whether this
24 is also the case in China, as the radius of trust is different between China and the US, where Chinese are more
25 prone to consider general trust as trust in strong ties, while Americans as trust in weak ties.⁴⁹ Additionally, a
26 rapidly developing society may also be accompanied by high social mobility and great social uncertainty, whereby
27 people do not have enough information to predict others' behaviors.²¹ In such a situation, people with a high trust
28 of others are less likely to worry about others' intention to harm them; hence, they might suffer from less anxiety.

29 On the other hand, we did not find consistent associations of individual-level civic participation with physical
30 and mental health. Previous studies showed mixed associations between individual-level civic participation and
31 health outcomes.^{46,50,51} We measured civic participation by voting in the neighborhood/village committee election.
32 Previous studies argued that local political participation (e.g., voting) could affect welfare policies provided by
33 governments.^{52,53} Nevertheless, neighborhood/village committees in China have no right to make policies.
34 Additionally, voting is a social- and political-specific indicator for civic participation, which may result in
35 inconsistent associations between civic participation and health in different societies.

36 We also did not find consistent associations of any community-level social capital indicators with physical or
37 mental health. Previous studies showed mixed results as to the associations between community-level social
38 capital and health.^{46,50,51,54} The mixed results may be due to different geographic scales where study areas were
39 located. For example, studies in the UK defined communities as post-code sectors,^{51,55} while studies in the US
40 measured community-level social capital at the state level.^{52,56} While a previous Chinese study measured
41 community-level social capital at the village level,⁴⁶ the present study measured community-level social capital
42 at the county level. Also, the social capital indicators in these studies were not the same; hence, it is difficult to
43 make meaningful comparisons with other studies.

44 It should be noticed that our social capital indicators are not exactly the same as in the previous Chinese
45 studies.^{13,50,57-60} The definition of social capital is still debatable and there is no single best measure of social
46 capital.² As we intended to make comparisons across years, we only used the variables which were included in all
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3 the years. In previous studies, one of the approaches on social capital measurement is “Position Generator”.⁶¹
4 Several Chinese studies found associations between social capital and health outcomes by using the “Position
5 Generator”.^{59,60,62} Previous Chinese studies also employed multiple items and combined the items as social capital
6 indexes.^{13,16,63–67} Other studies employed different single items as different dimensions of social capital. For
7 example, studies used social relationship⁶⁸ and organization membership^{50,69,70} as structural social capital, and
8 trust as cognitive social capital.^{62,68,71} Trust is the most common measurement of social capital shown to be
9 associated with different health outcomes, which was consistent with our results. However, we used frequency of
10 socializing and voting behavior as structural social capital, which were not commonly used in previous studies.
11 The difference in measurements should be taken into account when comparing our results with results in other
12 studies.
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17 **Strengths and limitations**

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19 A major strength of our study is the comparability of the associations between multilevel social capital and health
20 outcomes over time. Hence, our consistent findings provided more solid evidence for associations of the
21 individual-level frequency of socializing and trust with physical and mental health beyond previous mixed results.
22 The other strength of our study is that we took advantage of a rapidly developing society (i.e., China) as a social
23 laboratory to observe the associations between multilevel social capital and health outcomes.
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25 A limitation of our study is that we cannot make causal inferences since this study is cross-sectional by nature.
26 However, our health outcomes were “current” physical health and mental health in the “past four weeks”, and our
27 frequency of socializing was socializing “in the past year”. The timeline helped us partially avoid reverse
28 associations between individual-level frequency of socializing and health outcomes. Secondly, we only included
29 generalized trust in cognitive social capital. While this measurement cannot directly capture community-specific
30 trust (e.g. trust in neighbors), it was used in previous studies.^{51,54,56,72} Thirdly, the study period was relatively short
31 (i.e., six years), which prohibited us from observing a more long-term trend of the association. However, as we
32 observed the association in a rapidly developing and changing society and the development and changes are
33 ongoing, we speculate that the associations we observed will remain in the long run. Fourthly, the two single-item
34 questions on measuring physical and mental health may be subject to validity and reliability issues. As compared
35 with multiple-item scales, the measurement errors of single-item questions may be higher. Nevertheless, previous
36 studies found that self-rated health was a predictor for mortality.⁷³ Further studies using established instruments
37 to assess physical and mental health are needed. Last but not least, we could not estimate the independent causal
38 effect of community-level social capital on individuals’ health. We used multilevel regression models instead of
39 aggregating individual-level responses to estimate the community-level social capital, taking individual
40 characteristics into account. However, we could not adjust for all individual characteristics in the models. Further
41 studies using other study designs, such as natural experiments or randomized community trials, are needed.
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49 **Conclusion**

50 Our findings suggest that individual-level social capital in terms of frequency of socializing and trust is a robust
51 social determinant of health during a period of rapid economic growth. Hence, improving individual-level social
52 capital for health promotion could be a long-term strategy even in a rapidly developing society. Interventions can
53 be designed to increase opportunities for socializing and to improve trust. Given that people with less socializing
54 and lower trust appear to be at a higher risk of poor health, interventions could consider a population segmentation
55 strategy based on social capital indicators to target individuals with lower frequency of socializing and lower trust.
56 It may be difficult for policies to target individuals directly, but they can be designed as a “nudge” for individuals’
57 socializing and trust. For example, governments can consider providing freely accessible public space (e.g., parks,
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activity centers) for people's social interaction, and they can also extend operation hours of public transports to encourage socialization. Trustworthy health-related information channels should also be established. On the other hand, policymakers may pay attention to avoid damaging social capital when implementing other policies.

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Competing interests We declare no competing interests.

Patient and public involvement Patients and/or the public were not involved in this research.

Patient consent for publication Not required.

Ethics approval No ethics review was needed for these secondary analyses of publicly available, anonymized data

Data availability statement The secondary data are available from Chinese National Survey Data Archive.

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Table 1. Sample Characteristics, 2010-2015

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	36.43	37.75	30.36	32.21
Good	63.57	62.25	69.64	67.79
Mental Health				
Poor	32.83	33.03	27.35	30.19
Good	67.17	66.97	72.65	69.81
Sociodemographic factors				
Gender				
Female	49.48	49.48	49.48	49.48
Male	50.52	50.52	50.52	50.52
Age (years)	42.76±16.35	42.76±16.39	42.74±16.36	42.74±16.38
Ethnicity				
Non-Han	9.97	9.82	9.64	8.68
Han	90.03	90.18	90.36	91.32
Marital status				
Single/separated/divorced/widowed	24.16	24.40	25.17	25.78
Cohabit/married	75.84	75.60	74.83	74.22
Socioeconomic factors				
Education				
Primary school or below	33.77	32.50	31.25	29.95
Junior secondary school	31.33	30.04	30.89	30.75
Senior secondary school or equal	19.35	19.85	19.64	19.66
College or above	15.55	17.62	18.22	19.64
Occupation [#]				
Skill 3 or 4	10.62	13.40	11.93	11.88
Skill 2	53.53	51.75	51.15	47.33
Skill 1	3.58	2.71	3.40	4.56
Non-employed	32.27	32.14	33.52	36.22
Poverty				
Poor	11.59	15.23	13.24	14.71
Non-poor	81.08	76.44	77.79	79.76
Do not know income	7.33	8.33	8.97	5.53
Place of residence				
Urban	51.76	51.76	51.76	51.76
Rural	48.24	48.24	48.24	48.24
Social capital				
Frequency of socializing				
Low	77.11	72.51	71.58	71.94

High	22.89	27.49	28.42	28.06
Civic participation				
No	55.78	54.06	58.48	56.44
Yes	44.22	45.94	41.52	43.56
Trust				
Low	35.44	37.34	45.13	37.92
High	64.56	62.66	54.87	62.08
Community level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	19.09±6.36	31.99±9.10	35.36±10.99	40.39±9.78
Civic participation (%)	24.62±12.65	21.02±9.79	17.74±9.77	21.03±10.82
Trust (%)	47.71±7.41	46.07±9.88	43.39±9.03	44.39±5.82

Weighted percentages for categorical variables and weighted means for continuous variables with standard deviations

Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations (for more details, please see Supplementary Material 2).

Table 2. Associations of individual-level and community-level social capital with physical health, 2010-2015 (Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.31*** (1.20,1.43)	1.30*** (1.19,1.42)	1.20*** (1.09,1.32)	1.31*** (1.19,1.43)
Age				
	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)
Ethnicity				
Non-Han	1	1	1	1
Han	0.89 (0.73,1.09)	1.02 (0.84,1.24)	0.94 (0.77,1.16)	1.08 (0.88,1.33)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.02 (0.90,1.14)	0.90 (0.81,1.01)	1.01 (0.90,1.14)	0.93 (0.83,1.04)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.18** (1.05,1.33)	1.20** (1.07,1.34)	1.27*** (1.13,1.43)	1.12 (1.00,1.26)
Senior secondary school or equal	1.31*** (1.14,1.51)	1.40*** (1.22,1.60)	1.49*** (1.28,1.73)	1.40*** (1.21,1.62)
College or above	1.42*** (1.18,1.70)	1.52*** (1.27,1.81)	1.60*** (1.32,1.94)	1.61*** (1.33,1.95)
Poverty				
Poor	1	1	1	1
Non-poor	1.58*** (1.38,1.82)	1.68*** (1.48,1.90)	1.64*** (1.44,1.87)	1.55*** (1.37,1.76)
Do not know income	1.54*** (1.24,1.93)	1.43*** (1.18,1.74)	1.49*** (1.23,1.81)	1.31* (1.05,1.64)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.89 (0.74,1.07)	0.94 (0.80,1.11)	0.94 (0.78,1.13)	0.96 (0.79,1.17)
Skill level 1	1.19 (0.89,1.58)	1.03 (0.77,1.37)	0.99 (0.74,1.34)	0.87 (0.66,1.16)
Non-employed	0.66*** (0.55,0.80)	0.77** (0.65,0.90)	0.63*** (0.52,0.76)	0.76** (0.63,0.93)
Place of residence				

Rural	1	1	1	1
Urban	1.08	1.13*	1.29***	1.29***
	(0.96,1.21)	(1.01,1.27)	(1.15,1.46)	(1.15,1.45)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.49***	1.39***	1.28***	1.36***
	(1.33,1.66)	(1.26,1.54)	(1.15,1.42)	(1.23,1.50)
Civic participation				
No	1	1	1	1
Yes	1.01	1.01	1.01	0.99
	(0.91,1.11)	(0.92,1.11)	(0.91,1.11)	(0.90,1.10)
Trust				
Low	1	1	1	1
High	1.34***	1.30***	1.21***	1.41***
	(1.22,1.47)	(1.18,1.42)	(1.10,1.33)	(1.28,1.55)
Community-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.00	1.01**
	(0.97,1.01)	(0.99,1.01)	(0.99,1.01)	(1.00,1.02)
Civic participation (%)				
	1.00	0.99	0.99	0.99**
	(0.99,1.01)	(0.98,1.00)	(0.98,1.00)	(0.98,1.00)
Trust (%)				
	1.00	1.01	1.01	1.01
	(0.99,1.02)	(1.00,1.02)	(0.99,1.02)	(1.00,1.03)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130
<i>ICC</i>	0.081	0.055	0.107	0.052

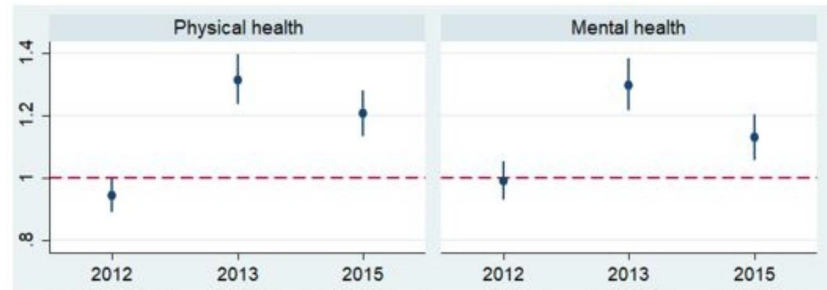
* p < 0.05, ** p < 0.01, *** p < 0.001

Table 3. Associations of individual-level and community-level social capital with mental health, 2010-2015 (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24*** (1.13,1.35)	1.32*** (1.21,1.44)	1.11* (1.01,1.22)	1.25*** (1.14,1.37)
Age				
	0.99*** (0.99,0.99)	0.99*** (0.99,1.00)	0.99*** (0.99,0.99)	0.99*** (0.99,1.00)
Ethnicity				
Non-Han	1	1	1	1
Han	0.87 (0.72,1.06)	1.06 (0.87,1.28)	0.94 (0.77,1.16)	0.99 (0.81,1.23)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.25*** (1.12,1.40)	1.21*** (1.09,1.35)	1.29*** (1.15,1.44)	1.21*** (1.08,1.35)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.35*** (1.20,1.51)	1.24*** (1.11,1.39)	1.23*** (1.09,1.39)	1.28*** (1.13,1.44)
Senior secondary school or equal	1.44*** (1.25,1.66)	1.53*** (1.33,1.76)	1.37*** (1.18,1.59)	1.62*** (1.40,1.88)
College or above	1.58*** (1.32,1.90)	1.51*** (1.27,1.80)	1.51*** (1.25,1.83)	1.71*** (1.42,2.07)
Poverty				
Poor	1	1	1	1
Non-poor	1.80*** (1.58,2.06)	1.77*** (1.57,1.99)	1.77*** (1.56,2.02)	1.54*** (1.36,1.74)
Do not know income	1.88*** (1.52,2.33)	1.55*** (1.28,1.87)	1.36** (1.13,1.65)	1.37** (1.11,1.71)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	1.01 (0.85,1.21)	1.01 (0.86,1.19)	1.03 (0.86,1.23)	1.21 (1.00,1.46)
Skill level 1	1.16 (0.88,1.54)	0.99 (0.75,1.32)	1.04 (0.77,1.40)	1.13 (0.86,1.50)
Non-employed	0.94 (0.79,1.13)	1.04 (0.89,1.23)	0.92 (0.77,1.11)	1.05 (0.87,1.27)
Place of residence				

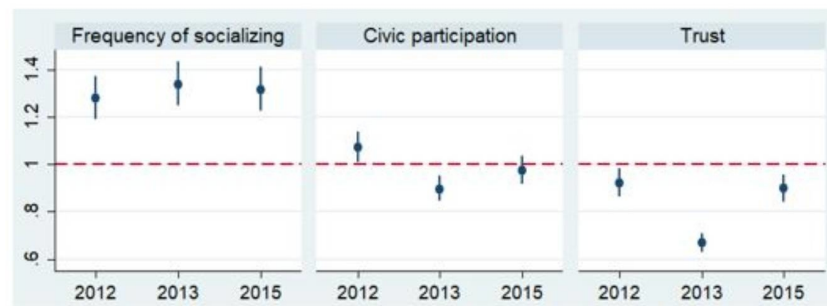
Rural	1	1	1	1
Urban	1.07	0.99	1.07	1.17**
	(0.96,1.20)	(0.88,1.11)	(0.95,1.21)	(1.04,1.31)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.27***	1.21***	1.30***	1.35***
	(1.14,1.42)	(1.09,1.34)	(1.17,1.45)	(1.22,1.50)
Civic participation				
No	1	1	1	1
Yes	0.98	1.04	1.17**	1.01
	(0.89,1.08)	(0.95,1.14)	(1.05,1.29)	(0.92,1.12)
Trust				
Low	1	1	1	1
High	1.47***	1.42***	1.36***	1.43***
	(1.34,1.61)	(1.30,1.56)	(1.24,1.49)	(1.30,1.57)
Community-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.00	1.01
	(0.98,1.01)	(0.99,1.01)	(0.99,1.01)	(1.00,1.02)
Civic participation (%)				
	1.01	1.01	1.00	1.00
	(1.00,1.01)	(1.00,1.02)	(0.98,1.01)	(1.00,1.01)
Trust (%)				
	0.99	1.01	1.00	1.00
	(0.98,1.00)	(1.00,1.02)	(0.98,1.01)	(0.99,1.02)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130
<i>ICC</i>	0.060	0.061	0.125	0.062

* p < 0.05, ** p < 0.01, *** p < 0.001



ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; "poor" physical health and "poor" mental health were references of the dependent variables in each model

Fig. 1a Trends of health outcomes, 2010-2015 ($N=42,829$)



ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; "low" frequency of socializing, "low" trust and "no" civic participation were references of the dependent variables in each model

Fig. 1b Trends of individual-level social capital, 2010-2015 ($N=42,829$)



Coefficients (β) with 95% CI were reported with 2010 as the reference year based on linear regression models

Fig. 1c Trends of community-level social capital, 2010-2015 ($N=520$)

Fig. 1 Trends of health outcomes, individual-level social capital and community-level social capital, 2010-2015

114x161mm (300 x 300 DPI)

Supplementary Materials and Data

Supplementary Material 1: Details of the questions for social capital indicators

Frequency of socializing We assessed respondents' frequency of socializing by the question "How often did you engage in social interactions in your spare time in the past year?" Responses were categorized into "low" (including "never", "seldom", and "sometimes") and "high" (including "often" and "very frequently") frequency.

Civic participation We assessed civic participation by the question "Did you vote in the latest neighborhood/village committee election?". According to related laws,^{1,2} neighborhood committees and village committees are the basic-level administrative units, and residents aged 18 or above in each neighborhood/village directly elect members to the two committees. Hence, voting in the election reflects people's willingness to participate in civic activities in a community. The voting rate in a community reflects the extent of a community's social cohesion, and this measurement has been used in several previous studies.³⁻⁶

Trust We measured respondents' trust of others based on the question "Generally speaking, do you agree that most people in the society are trustworthy?" Responses were categorized into "low" (including "strongly disagree", "disagree", and "neutral") and "high" (including "agree" and "strongly agree") trust.

Supplementary Material 2: Calculation of community-level social capital

We calculate community-level by using two-level binary logistic regressions with individuals at Level 1 nested within communities at Level 2. Following a previous study,⁷ we estimated the variance component in each individual-level social capital variable that can be attributed to communities separately. This method was also used in several multilevel social capital studies.⁸⁻¹⁰ We adjusted for individual characteristics that can influence each individual-level social capital variable, including gender (male, female), age (years), ethnicity (*Han*, non-*Han*), marital status (married/cohabitation, never married/divorced/separated/widowed), education (primary school or below, junior secondary school, senior secondary school, and college or above), occupation, poverty, and places of residence (rural, urban).

Taking y_{ij} as a binary response on a social capital variable for respondent i in community j , the regression model was specified as follows:

$$\text{Log} \left(\frac{p_{ij}}{1 - p_{ij}} \right) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \dots + \beta_p x_{pij} + \mu_j$$

where $p_{ij} = \text{Pr}(y_{ij}=1)$, β_0 is the grand mean of the social capital variable, x_{pij} is the p th individual characteristics for respondent i in community j , and μ_j is the random effect at Level 2, i.e., the residuals at community level.

Based on the regression model above, the community-level social capital of community j was calculated by the sum of β_0 and μ_j . We transformed the coefficient to probability, i.e., $p_{ij} = \frac{e^{(\beta_0 + \mu_j)}}{1 + e^{(\beta_0 + \mu_j)}}$, which means the probability of $y_{ij}=1$ for community j in which respondent i lived after adjusting for individual characteristics. In other words, it is the probability of $y_{ij}=1$ that can be attributed to communities after adjusting for individual characteristics (i.e., compositional factors). Hence, it is the contextual construct of social capital at community level.⁷ We reported the probability as a percentage. Higher percentage indicated higher community-level social capital.

We performed the above regression model for each of the three social capital variables (i.e., frequency

of socializing, civic participation, and trust) in each year. For example, if y_{ij} is a response on trust (1=high trust, 0=low trust) for respondent i in community j in 2010, then p_{ij} is the probability of high trust in community j where respondent i lived in 2010 after adjusting for individual characteristics of respondent i . In other words, if respondent i lived in community j in 2010, then taking other individual characteristics into account, the probability of he/she having high trust was p_{ij} and this probability, p_{ij} , could be attributed to living in community j .

Supplementary Material 3: Details of occupation and poverty

We classified occupation according to the International Standard Classification of Occupations 2008 (ISCO-08) (i.e., Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations).¹¹ We further included students, the unemployed, and retired people as “non-employed.”

We assessed poverty by equivalized household income, which was calculated by dividing household income by the squared root of the number of household members. We defined respondents as “poor” if their equivalized household annual incomes were less than or equal to half of the median equivalized household annual income in each survey year. We further included “do not know income” as a separate category.

Supplementary Material 4: The weighting method used for two-level regression models

Studies have indicated that it is required to use scaling weights instead of the “raw” weights in multilevel models.^{12–14} Following previous studies,^{12,15} we calculated scaled individual-level weights as below:

$$w_{ij}^* = w_{ij} \left(\frac{n_j}{\sum_i w_{ij}} \right)$$

where w_{ij}^* is the scaled weight for individual i in cluster j , w_{ij} is the unscaled weight for individual i in cluster j , and n_j is the sample size in cluster j . Each county represents one cluster in our study.

Supplementary Material 5: Supplementary Tables**Supplementary Table 1. Missing data**

	2010	2012	2013	2015
	Total = 11,783	Total = 11,765	Total = 11,438	Total = 10,968
Gender	0	0	0	0
Age	9	4	2	0
Ethnicity	22	9	12	20
Marital status	8	0	23	0
Education	15	4	6	29
Annual household income	758	548	614	348
Number of household member	0	0	0	0
Occupation	80	74	107	218
Frequency of socializing	76	8	4	6
Trust	21	6	14	41
Civic participation	28	11	15	102
Place of residence	0	0	0	0
Physical health	15	4	2	7
Mental health	51	17	21	26

Supplementary Table 2. Unweighted sample characteristics

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	41.71	44.09	35.81	40.12
Good	58.29	55.91	64.19	59.88
Mental Health				
Poor	34.24	34.77	28.79	32.34
Good	65.76	65.23	71.21	67.66
Sociodemographic factors				
Gender				
Female	51.79	48.83	49.85	53.10
Male	48.21	51.17	50.15	46.90
Age (years)	47.50±15.66	49.07±16.22	48.72±16.44	50.61±16.91
Ethnicity				
Non-Han	9.11	8.79	8.59	7.96
Han	90.89	91.21	91.41	92.04
Marital status				
Single/separated/divorced/widowed	19.44	19.92	21.00	21.71
Cohabit/married	80.56	80.08	79.00	78.29
Socioeconomic factors				
Education				
Primary school or below	36.92	37.23	36.18	38.21
Junior secondary school	29.52	28.31	29.04	28.52
Senior secondary school or equal	19.13	18.86	18.88	17.81
College or above	14.44	15.60	15.90	15.46
Occupation				
Skill 3 or 4	10.32	12.81	11.54	9.83
Skill 2	50.12	48.06	47.25	42.61
Skill 1	3.61	2.88	3.48	4.14
Non-employed	35.96	36.25	37.74	43.42
Poverty				
Poor	12.08	16.38	14.67	17.10
Non-poor	81.68	76.31	77.06	77.54
Do not know income	6.24	7.30	8.27	5.36
Place of residence				
Urban	59.64	59.68	59.98	57.82
Rural	40.36	40.32	40.02	42.18
Social capital				
Frequency of socializing				
Low	78.05	74.07	72.29	72.26
High	21.95	25.93	27.71	27.74
Civic participation				

No	53.59	50.93	56.13	52.87
Yes	46.41	49.07	43.87	47.13
Trust				
Low	33.92	35.27	43.62	35.89
High	66.08	64.73	56.38	64.11
Community level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	19.57±6.38	31.43±8.58	34.66±11.25	38.95±9.61
Civic participation (%)	25.17±12.15	21.13±9.99	18.77±10.68	22.87±14.25
Trust (%)	46.87±7.29	45.80±9.25	42.23±10.31	43.92±6.36

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Supplementary Table 3. Associations of individual-level and community-level social capital with physical health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” physical health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.50*** (1.30,1.74)	1.38*** (1.20,1.59)	1.19* (1.03,1.38)	1.37*** (1.19,1.57)	1.19** (1.06,1.33)	1.24*** (1.11,1.39)	1.20** (1.06,1.36)	1.24*** (1.10,1.41)
Age	0.96*** (0.95,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.97)	0.97*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	1.01 (0.74,1.37)	0.99 (0.75,1.30)	0.79 (0.59,1.06)	1.17 (0.88,1.56)	0.80 (0.61,1.05)	1.00 (0.77,1.30)	1.27 (0.95,1.69)	1.01 (0.76,1.34)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.02 (0.83,1.26)	0.98 (0.81,1.19)	0.96 (0.79,1.17)	1.00 (0.83,1.21)	1.03 (0.89,1.19)	0.87 (0.75,1.00)	1.04 (0.90,1.22)	0.89 (0.76,1.03)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.39*** (1.17,1.64)	1.49*** (1.27,1.74)	1.64*** (1.39,1.95)	1.24* (1.05,1.47)	0.97 (0.82,1.14)	0.92 (0.79,1.08)	0.94 (0.79,1.12)	1.02 (0.87,1.21)

5	Senior secondary school or equal	1.49**	1.53**	1.54**	2.08***	1.15	1.18	1.25*	1.21*
6		(1.14,1.96)	(1.18,1.99)	(1.17,2.03)	(1.57,2.75)	(0.97,1.36)	(0.99,1.40)	(1.04,1.52)	(1.00,1.45)
7	College or above	1.60	2.77***	3.18***	1.78*	1.26*	1.25*	1.28*	1.46***
8		(0.84,3.04)	(1.53,5.00)	(1.72,5.89)	(1.09,2.89)	(1.02,1.55)	(1.02,1.52)	(1.02,1.60)	(1.17,1.83)
10	Poverty								
11	Poor	1	1	1	1	1	1	1	1
12	Non-poor	1.70***	1.59***	1.56***	1.60**	1.25	1.73***	1.83***	1.54***
13		(1.42,2.03)	(1.36,1.87)	(1.31,1.85)	(1.37,1.88)	(0.98,1.60)	(1.39,2.15)	(1.46,2.30)	(1.24,1.91)
14	Do not know income	1.58**	1.54**	1.28	1.02	1.24	1.33	1.71***	1.53*
15		(1.13,2.19)	(1.17,2.03)	(0.98,1.69)	(0.74,1.41)	(0.89,1.73)	(0.98,1.79)	(1.26,2.32)	(1.10,2.14)
17	Occupation								
19	Skill level 3 or 4	1	1	1	1	1	1	1	1
20	Skill level 2	0.91	0.88	0.78	1.17	0.89	0.97	1.00	0.97
21		(0.56,1.48)	(0.58,1.36)	(0.48,1.26)	(0.73,1.86)	(0.73,1.09)	(0.82,1.16)	(0.82,1.23)	(0.78,1.22)
22	Skill level 1	1.53	1.24	1.03	1.29	1.04	0.89	0.93	0.73
23		(0.79,2.94)	(0.66,2.30)	(0.53,1.99)	(0.72,2.28)	(0.75,1.45)	(0.64,1.24)	(0.66,1.32)	(0.52,1.03)
24	Non-employed	0.64	0.74	0.49**	1.00	0.65***	0.74**	0.64***	0.70**
25		(0.39,1.06)	(0.48,1.15)	(0.30,0.80)	(0.62,1.60)	(0.53,0.80)	(0.61,0.88)	(0.52,0.80)	(0.56,0.87)
28	Individual-level social capital								
29	Frequency of socializing								
31	Low	1	1	1	1	1	1	1	1
32	High	1.45***	1.50***	1.28**	1.37***	1.51***	1.33***	1.27**	1.34***
33		(1.19,1.76)	(1.27,1.78)	(1.10,1.50)	(1.19,1.59)	(1.31,1.73)	(1.17,1.51)	(1.09,1.47)	(1.15,1.55)
34	Civic participation								
36	No	1	1	1	1	1	1	1	1
37	Yes	1.04	1.00	0.89	0.88	0.97	1.01	1.12	1.09

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5		(0.88,1.21)	(0.86,1.16)	(0.77,1.04)	(0.76,1.02)	(0.85,1.10)	(0.90,1.14)	(0.98,1.29)	(0.95,1.25)
6	Trust								
7	Low	1	1	1	1	1	1	1	1
8	High	1.24**	1.26**	1.07	1.40***	1.39***	1.31***	1.35***	1.41***
9		(1.06,1.45)	(1.09,1.46)	(0.92,1.24)	(1.21,1.62)	(1.23,1.56)	(1.17,1.47)	(1.20,1.54)	(1.24,1.59)
10	Community-level social capital								
11	High frequency of socializing (%)	0.99	1.01	1.00	1.01*	0.99	1.00	1.00	1.01**
12		(0.96,1.01)	(0.99,1.02)	(0.98,1.01)	(1.00,1.03)	(0.97,1.01)	(0.99,1.01)	(0.99,1.02)	(1.00,1.02)
13	Civic participation (%)	1.01	1.00	1.00	0.99	1.00	0.99*	0.98*	0.99**
14		(0.99,1.02)	(0.99,1.02)	(0.99,1.02)	(0.98,1.01)	(0.99,1.00)	(0.98,1.00)	(0.97,1.00)	(0.98,1.00)
15	Trust (%)	1.00	1.01	1.01	1.01	1.00	1.01	1.00	1.01
16		(0.97,1.02)	(0.99,1.02)	(0.99,1.03)	(0.99,1.03)	(0.99,1.02)	(1.00,1.02)	(0.99,1.01)	(0.99,1.03)
17	<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
18	<i>N of communities</i> [#]	89	87	86	87	129	125	121	124
19	<i>ICC</i>	0.122	0.059	0.092	0.058	0.069	0.046	0.116	0.049

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] One community (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of communities in our study is not equal to the sum of the number of communities in rural samples and the number of communities in urban samples.

Supplementary Table 4. Associations of individual-level and community-level social capital with mental health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” mental health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.41*** (1.22,1.61)	1.47*** (1.28,1.69)	1.11 (0.96,1.29)	1.41*** (1.23,1.63)	1.13* (1.01,1.27)	1.24*** (1.10,1.38)	1.13 (1.00,1.27)	1.16* (1.02,1.31)
Age	0.98*** (0.98,0.99)	0.98*** (0.98,0.99)	0.99*** (0.99,1.00)	0.99*** (0.98,0.99)	0.99** (0.99,1.00)	1.00 (0.99,1.00)	0.99*** (0.98,0.99)	1.00 (0.99,1.00)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	0.89 (0.67,1.20)	0.91 (0.69,1.20)	0.86 (0.64,1.16)	0.97 (0.72,1.30)	0.93 (0.71,1.21)	1.26 (0.98,1.63)	1.19 (0.90,1.58)	1.16 (0.88,1.54)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.16 (0.96,1.40)	1.13 (0.94,1.35)	1.46*** (1.21,1.75)	1.19* (1.00,1.43)	1.27*** (1.11,1.46)	1.21** (1.06,1.39)	1.20* (1.03,1.39)	1.19* (1.03,1.37)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.33*** (1.13,1.57)	1.26** (1.07,1.48)	1.42*** (1.19,1.70)	1.09 (0.92,1.29)	1.30** (1.11,1.53)	1.18* (1.00,1.39)	1.05 (0.88,1.25)	1.43*** (1.21,1.69)

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Senior secondary school or equal	1.46**	1.39*	1.28	1.48**	1.44***	1.54***	1.31**	1.76***
	(1.12,1.90)	(1.06,1.82)	(0.97,1.69)	(1.12,1.94)	(1.21,1.71)	(1.30,1.84)	(1.08,1.59)	(1.46,2.12)
College or above	1.27	2.16**	3.48***	1.57	1.68***	1.51***	1.31*	1.94***
	(0.70,2.29)	(1.21,3.85)	(1.97,6.16)	(0.99,2.49)	(1.37,2.07)	(1.24,1.85)	(1.05,1.64)	(1.55,2.42)
Poverty								
Poor	1	1	1	1	1	1	1	1
Non-poor	1.69***	1.60***	1.78***	1.54***	1.77***	1.77***	1.77***	1.41**
	(1.43,2.01)	(1.37,1.87)	(1.50,2.11)	(1.31,1.80)	(1.40,2.22)	(1.43,2.18)	(1.42,2.22)	(1.14,1.74)
Do not know income	2.23***	1.49**	1.27	1.22	1.65**	1.61**	1.43*	1.45*
	(1.62,3.07)	(1.14,1.95)	(0.98,1.65)	(0.89,1.67)	(1.21,2.26)	(1.20,2.14)	(1.07,1.93)	(1.05,1.99)
Occupation								
Skill level 3 or 4	1	1	1	1	1	1	1	1
Skill level 2	0.73	0.91	1.00	1.28	1.04	0.98	0.96	1.14
	(0.45,1.18)	(0.59,1.43)	(0.62,1.61)	(0.81,2.01)	(0.86,1.26)	(0.82,1.17)	(0.79,1.17)	(0.92,1.42)
Skill level 1	0.66	0.61	0.95	1.22	1.34	1.16	1.04	1.03
	(0.35,1.21)	(0.32,1.13)	(0.49,1.82)	(0.69,2.14)	(0.96,1.87)	(0.83,1.62)	(0.74,1.47)	(0.73,1.44)
Non-employed	0.58*	0.85	0.70	1.05	1.00	1.01	0.99	1.00
	(0.36,0.95)	(0.54,1.34)	(0.43,1.15)	(0.66,1.65)	(0.82,1.22)	(0.85,1.22)	(0.80,1.22)	(0.81,1.24)
Individual-level social capital								
Frequency of socializing								
Low	1	1	1	1	1	1	1	1
High	1.11	1.25*	1.36***	1.54***	1.34***	1.18**	1.23**	1.17*
	(0.92,1.34)	(1.05,1.47)	(1.17,1.59)	(1.33,1.79)	(1.17,1.54)	(1.04,1.34)	(1.06,1.43)	(1.01,1.35)
Civic participation								
No	1	1	1	1	1	1	1	1
Yes	0.89	1.00	1.03	0.89	1.02	1.04	1.29***	1.13

	(0.77,1.04)	(0.86,1.15)	(0.89,1.21)	(0.76,1.03)	(0.90,1.16)	(0.92,1.18)	(1.12,1.48)	(0.99,1.30)
Trust								
Low	1	1	1	1	1	1	1	1
High	1.43***	1.36***	1.21**	1.58***	1.47***	1.48***	1.48***	1.33***
	(1.23,1.66)	(1.18,1.57)	(1.05,1.41)	(1.37,1.83)	(1.31,1.65)	(1.32,1.65)	(1.31,1.67)	(1.17,1.50)
Community-level social capital								
Frequency of socializing (%)	0.99	1.00	1.00	1.02**	0.99	1.00	1.00	1.00
	(0.97,1.01)	(0.99,1.02)	(0.98,1.01)	(1.01,1.03)	(0.98,1.01)	(0.99,1.01)	(0.99,1.01)	(0.99,1.02)
Civic participation (%)	1.01	1.01	1.00	1.00	1.01	1.01	1.00	1.00
	(1.00,1.02)	(1.00,1.02)	(0.99,1.02)	(0.99,1.01)	(1.00,1.02)	(1.00,1.02)	(0.99,1.02)	(0.99,1.01)
Trust (%)	0.99	1.01	1.00	1.00	0.99	1.01*	0.99	1.00
	(0.97,1.01)	(0.99,1.02)	(0.98,1.02)	(0.98,1.03)	(0.98,1.00)	(1.00,1.02)	(0.98,1.01)	(0.99,1.02)
<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
<i>N of communities</i> [#]	89	87	86	87	129	125	121	124
<i>ICC</i>	0.084	0.077	0.106	0.072	0.054	0.060	0.130	0.053

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[#] One community (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of communities in our study is not equal to the sum of the number of communities in rural samples and the number of communities in urban samples.

Supplementary Table 5. Associations of individual-level and community-level social capital, national GDP, and annually national GDP growth with physical health and mental health, pooled data from 2010-2015 (Multi-level binary logistic model, with “poor” physical health and “poor” mental health as references)

	Two-level models without GDP		Three-level models with GDP		Three-level models with GDP Growth	
	Physical health	Mental health	Physical health	Mental health	Physical health	Mental health
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors						
Gender						
Female	1	1	1	1	1	1
Male	1.28*** (1.23,1.34)	1.23*** (1.18,1.28)	1.28*** (1.23,1.34)	1.23*** (1.18,1.28)	1.28*** (1.23,1.34)	1.23*** (1.17,1.28)
Age	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)
Ethnicity						
Non-Han	1	1	1	1	1	1
Han	0.98 (0.89,1.09)	0.95 (0.86,1.05)	0.98 (0.89,1.09)	0.96 (0.87,1.07)	0.98 (0.89,1.09)	0.96 (0.87,1.07)
Marriage						
Single/separated/divorced/widowed	1	1	1	1	1	1
Cohabit/married	0.95 (0.90,1.01)	1.23*** (1.17,1.30)	0.96 (0.91,1.02)	1.24*** (1.17,1.31)	0.96 (0.91,1.02)	1.24*** (1.17,1.31)
Socioeconomic factors						
Education						
Primary school or below	1	1	1	1	1	1
Junior secondary school	1.18***	1.27***	1.19***	1.27***	1.19***	1.27***

	(1.11,1.25)	(1.19,1.34)	(1.13,1.26)	(1.20,1.35)	(1.13,1.26)	(1.20,1.35)
Senior secondary school or equal	1.38***	1.47***	1.40***	1.48***	1.40***	1.48***
	(1.29,1.48)	(1.37,1.58)	(1.30,1.50)	(1.38,1.59)	(1.30,1.50)	(1.38,1.59)
College or above	1.48***	1.53***	1.53***	1.56***	1.53***	1.56***
	(1.35,1.62)	(1.40,1.67)	(1.40,1.68)	(1.43,1.71)	(1.40,1.68)	(1.43,1.71)
Poverty						
Poor	1	1	1	1	1	1
Non-poor	1.62***	1.68***	1.62***	1.71***	1.62***	1.71***
	(1.52,1.73)	(1.58,1.79)	(1.52,1.73)	(1.61,1.82)	(1.52,1.73)	(1.61,1.82)
Do not know income	1.43***	1.52***	1.44***	1.51***	1.44***	1.51***
	(1.29,1.58)	(1.38,1.67)	(1.30,1.60)	(1.36,1.66)	(1.30,1.60)	(1.36,1.66)
Occupation						
Skill level 3 or 4	1	1	1	1	1	1
Skill level 2	0.94	1.08	0.94	1.06	0.94	1.06
	(0.87,1.03)	(0.99,1.17)	(0.86,1.02)	(0.97,1.16)	(0.86,1.02)	(0.97,1.16)
Skill level 1	1.02	1.07	1.01	1.08	1.01	1.08
	(0.88,1.17)	(0.93,1.23)	(0.87,1.16)	(0.94,1.24)	(0.87,1.16)	(0.94,1.24)
Non-employed	0.72***	0.99	0.71***	0.99	0.71***	0.99
	(0.65,0.78)	(0.91,1.08)	(0.65,0.77)	(0.90,1.08)	(0.65,0.77)	(0.90,1.08)
Place of residence						
Rural	1	1	1	1	1	1
Urban	1.20***	1.06*	1.20***	1.07*	1.20***	1.07*
	(1.13,1.27)	(1.00,1.12)	(1.13,1.27)	(1.01,1.13)	(1.13,1.27)	(1.01,1.13)
Individual-level social capital						
Frequency of socializing						
Low	1	1	1	1	1	1

High	1.34*** (1.27,1.41)	1.27*** (1.21,1.33)	1.37*** (1.30,1.44)	1.28*** (1.22,1.35)	1.36*** (1.30,1.44)	1.28*** (1.22,1.35)
Civic participation						
No	1 (0.95,1.05)	1 (0.99,1.09)	1 (0.96,1.06)	1 (1.00,1.10)	1 (0.96,1.06)	1 (1.00,1.10)
Yes	1.00 (0.95,1.05)	1.04 (0.99,1.09)	1.01 (0.96,1.06)	1.05 (1.00,1.10)	1.01 (0.96,1.06)	1.04 (1.00,1.10)
Trust						
Low	1 (1.23,1.35)	1 (1.33,1.46)	1 (1.25,1.37)	1 (1.36,1.49)	1 (1.25,1.37)	1 (1.36,1.49)
High	1.29*** (1.23,1.35)	1.39*** (1.33,1.46)	1.31*** (1.25,1.37)	1.42*** (1.36,1.49)	1.31*** (1.25,1.37)	1.42*** (1.36,1.49)
Community-level social capital						
Frequency of socializing (%)	1.01*** (1.00,1.01)	1.01*** (1.00,1.01)	1.00 (1.00,1.01)	1.00 (0.99,1.01)	1.00 (1.00,1.01)	1.00 (0.99,1.01)
Civic participation (%)	0.99*** (0.99,1.00)	1.00 (1.00,1.00)	0.99** (0.99,1.00)	1.00 (1.00,1.01)	0.99** (0.99,1.00)	1.00 (1.00,1.01)
Trust (%)	1.00 (1.00,1.01)	1.00 (1.00,1.01)	1.01* (1.00,1.01)	1.00 (0.99,1.01)	1.01* (1.00,1.01)	1.00 (0.99,1.01)
Year						
National GDP (trillion yuan)	--	--	1.01 (1.00,1.02)	1.01 (1.00,1.02)	--	--
Annually National GDP Growth (%)	--	--	--	--	0.95 (0.85,1.06)	0.95 (0.87,1.04)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>N of communities</i>	520	520	520	520	520	520
<i>N of years</i>	--	--	4	4	4	4
<i>ICC (At year level)</i>	--	--	0.004	0.003	0.005	0.003

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ICC (At community level)

0.041

0.040

0.079

0.080

0.081

0.081

* p < 0.05, ** p < 0.01, *** p < 0.001

1 trillion *yuan* ≈ 141 billion US\$

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Supplementary Table 6. Interaction effects between social capital indicators and survey year on physical health, pooled data from 2010-2015 (Two-level binary logistic model, with “poor” physical health as references)

	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Interaction term						
<i>Individual-level social capital</i>						
High frequency of socializing × 2010	1	--	--	--	--	--
High frequency of socializing × 2012	0.95 (0.82,1.10)	--	--	--	--	--
High frequency of socializing × 2013	0.88 (0.76,1.01)	--	--	--	--	--
High frequency of socializing × 2015	1.01 (0.87,1.16)	--	--	--	--	--
Civic participation (Yes) × 2010	--	1	--	--	--	--
Civic participation (Yes) × 2012	--	0.93 (0.83,1.05)	--	--	--	--
Civic participation (Yes) × 2013	--	0.91 (0.81,1.03)	--	--	--	--
Civic participation (Yes) × 2015	--	0.91 (0.81,1.03)	--	--	--	--
High trust × 2010	--	--	1	--	--	--
High trust × 2012	--	--	0.98 (0.87,1.11)	--	--	--
High trust × 2013	--	--	0.90 (0.79,1.02)	--	--	--
High trust × 2015	--	--	1.08	--	--	--

				(0.95,1.22)		
Community-level social capital						
High frequency of socializing × 2010	--	--	--		--	--
High frequency of socializing × 2012	--	--	--	1.00 (0.99,1.00)	--	--
High frequency of socializing × 2013	--	--	--	1.00 (1.00,1.00)	--	--
High frequency of socializing × 2015	--	--	--	1.02 (1.01,1.00)	--	--
Civic participation (Yes) × 2010	--	--	--		1	--
Civic participation (Yes) × 2012	--	--	--		0.99* (0.99,1.00)	--
Civic participation (Yes) × 2013	--	--	--		1.00 (0.99,1.00)	--
Civic participation (Yes) × 2015	--	--	--		1.00 (0.99,1.00)	--
High trust × 2010	--	--	--		--	1
High trust × 2012	--	--	--		--	1.00 (0.99,1.01)
High trust × 2013	--	--	--		--	1.00 (0.99,1.01)
High trust × 2015	--	--	--		--	1.00 (0.99,1.01)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>ICC</i>	0.043	0.043	0.043	0.043	0.043	0.043

* p < 0.05, ** p < 0.01, *** p < 0.001; Year and all other variables in Table 2 and Table 3 are adjusted.

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Supplementary Table 7. Interaction effects between social capital indicators and survey year on mental health, pooled data from 2010-2015 (Two-level binary logistic model, with “poor” mental health as references)

	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Interaction term						
<i>Individual-level social capital</i>						
High frequency of socializing × 2010	1	--	--	--	--	--
High frequency of socializing × 2012	0.93 (0.81,1.08)	--	--	--	--	--
High frequency of socializing × 2013	1.03 (0.89,1.19)	--	--	--	--	--
High frequency of socializing × 2015	1.10 (0.95,1.27)	--	--	--	--	--
Civic participation (Yes) × 2010	--	1	--	--	--	--
Civic participation (Yes) × 2012	--	1.09 (0.97,1.22)	--	--	--	--
Civic participation (Yes) × 2013	--	1.13 (1.00,1.27)	--	--	--	--
Civic participation (Yes) × 2015	--	1.02 (0.90,1.15)	--	--	--	--
High trust × 2010	--	--	1	--	--	--
High trust × 2012	--	--	1.04 (0.92,1.17)	--	--	--
High trust × 2013	--	--	0.96 (0.85,1.08)	--	--	--
High trust × 2015	--	--	1.02	--	--	--

				(0.90,1.16)		
Community-level social capital						
High frequency of socializing × 2010	--	--	--		--	--
High frequency of socializing × 2012	--	--	--	(1.00,1.00)	--	--
High frequency of socializing × 2013	--	--	--	(1.00,1.00)	--	--
High frequency of socializing × 2015	--	--	--	1.02*	--	--
				(1.01,1.00)		
Civic participation (Yes) × 2010	--	--	--		1	--
Civic participation (Yes) × 2012	--	--	--		1.00	--
					(0.99,1.00)	
Civic participation (Yes) × 2013	--	--	--		0.99*	--
					(0.99,1.00)	
Civic participation (Yes) × 2015	--	--	--		1.00	--
					(0.99,1.00)	
High trust × 2010	--	--	--		--	1
High trust × 2012	--	--	--		--	1.01***
						(1.01,1.02)
High trust × 2013	--	--	--		--	1.01*
						(1.00,1.02)
High trust × 2015	--	--	--		--	1.01
						(1.00,1.02)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>ICC</i>	0.040	0.040	0.040	0.040	0.040	0.040

* p < 0.05, ** p < 0.01, *** p < 0.001; Year and all other variables in Table 2 and Table 3 are adjusted.

Supplementary Table 8. Associations of individual-level and community-level social capital with physical health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24** (1.08,1.43)	1.38*** (1.23,1.55)	1.14* (1.02,1.28)	1.29*** (1.14,1.46)
Age	0.96*** (0.95,0.96)	0.96*** (0.95,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)
Ethnicity				
Non-Han	1	1	1	1
Han	0.86 (0.73,1.01)	0.92 (0.73,1.15)	0.91 (0.65,1.26)	0.97 (0.76,1.25)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	0.92 (0.80,1.04)	0.95 (0.78,1.15)	1.10 (0.92,1.32)	0.92 (0.80,1.07)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.33*** (1.15,1.53)	1.25** (1.09,1.43)	1.48*** (1.22,1.79)	1.29** (1.09,1.53)
Senior secondary school or equal	1.40*** (1.18,1.67)	1.55*** (1.30,1.83)	1.74*** (1.42,2.13)	1.65*** (1.37,1.98)
College or above	1.61*** (1.30,2.00)	1.63*** (1.27,2.08)	2.09*** (1.64,2.66)	1.92*** (1.53,2.42)
Poverty				
Poor	1	1	1	1
Non-poor	1.66*** (1.39,1.97)	1.54*** (1.31,1.81)	1.57*** (1.33,1.87)	1.59*** (1.34,1.88)
Do not know income	1.60*** (1.24,2.07)	1.55*** (1.23,1.95)	1.55*** (1.22,1.96)	1.24 (0.91,1.68)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.87 (0.70,1.07)	0.83 (0.64,1.07)	0.81 (0.64,1.02)	1.03 (0.81,1.30)
Skill level 1	1.37 (0.94,1.99)	0.79 (0.54,1.17)	0.99 (0.74,1.33)	1.03 (0.73,1.47)
Non-employed	0.69** (0.55,0.87)	0.74** (0.59,0.93)	0.62*** (0.50,0.77)	0.89 (0.70,1.13)

Place of residence				
Rural	1	1	1	1
Urban	1.01	1.10	1.15	1.18*
	(0.86,1.19)	(0.96,1.24)	(0.99,1.33)	(1.01,1.38)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.48***	1.40***	1.17*	1.26**
	(1.29,1.70)	(1.24,1.59)	(1.03,1.33)	(1.08,1.48)
Civic participation				
No	1	1	1	1
Yes	0.96	1.10	0.97	0.97
	(0.84,1.10)	(0.96,1.25)	(0.85,1.10)	(0.85,1.11)
Trust [#]				
Low	1	1	1	1
High	1.35***	1.32***	1.14	1.46***
	(1.21,1.52)	(1.17,1.48)	(0.99,1.30)	(1.28,1.67)
Community-level social capital				
Frequency of socializing (%)	0.98*	1.01	1.00	1.02***
	(0.96,1.00)	(1.00,1.02)	(0.99,1.02)	(1.01,1.03)
Civic participation (%)	1.00	1.00	0.99	0.99
	(0.99,1.01)	(0.99,1.01)	(0.98,1.01)	(0.99,1.00)
Trust (%)	0.99	1.01	1.01	1.01
	(0.97,1.01)	(0.99,1.02)	(1.00,1.03)	(1.00,1.03)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130
<i>ICC</i>	0.096	0.059	0.093	0.043

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] p = 0.063 in 2013

Supplementary Table 9. Associations of individual-level and community-level social capital with mental health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010		2012		2013		2015	
	Adjusted	OR	Adjusted	OR	Adjusted	OR	Adjusted	OR
	(95% CI)		(95% CI)		(95% CI)		(95% CI)	
Sociodemographic factors								
Gender								
Female		1		1		1		1
Male		1.22***		1.48***		1.04		1.30***
		(1.09,1.38)		(1.33,1.65)		(0.91,1.18)		(1.15,1.45)
Age								
		0.98***		0.98***		0.99***		0.99***
		(0.98,0.99)		(0.98,0.99)		(0.98,0.99)		(0.99,1.00)
Ethnicity								
Non-Han		1		1		1		1
Han		0.80*		0.98		0.93		0.93
		(0.66,0.98)		(0.79,1.21)		(0.68,1.28)		(0.74,1.15)
Marriage								
Single/separated/divorced/widowed		1		1		1		1
Cohabit/married		1.23**		1.16		1.47***		1.32***
		(1.06,1.43)		(0.99,1.35)		(1.24,1.73)		(1.12,1.55)
Socioeconomic factors								
Education								
Primary school or below		1		1		1		1
Junior secondary school		1.34***		1.23**		1.41***		1.31***
		(1.17,1.53)		(1.05,1.42)		(1.16,1.71)		(1.12,1.54)
Senior secondary school or equal		1.33**		1.62***		1.57**		1.65***
		(1.11,1.59)		(1.34,1.96)		(1.15,2.14)		(1.34,2.03)
College or above		1.43**		1.45***		2.02***		1.94***
		(1.12,1.81)		(1.17,1.80)		(1.47,2.77)		(1.51,2.48)
Poverty								
Poor		1		1		1		1
Non-poor		1.71***		1.58***		1.65***		1.55***
		(1.47,2.00)		(1.37,1.81)		(1.41,1.94)		(1.33,1.81)
Do not know income		1.92***		1.39**		1.34*		1.46*
		(1.48,2.50)		(1.10,1.77)		(1.07,1.67)		(1.09,1.95)
Occupation								
Skill level 3 or 4		1		1		1		1
Skill level 2		0.98		0.88		1.17		1.31*
		(0.78,1.24)		(0.70,1.10)		(0.87,1.56)		(1.01,1.69)
Skill level 1		0.94		0.65*		1.28		1.54
		(0.66,1.34)		(0.46,0.92)		(0.81,2.03)		(0.98,2.42)
Non-employed		0.94		0.95		1.10		1.20
		(0.75,1.18)		(0.76,1.20)		(0.80,1.50)		(0.92,1.55)

Place of residence				
Rural	1	1	1	1
Urban	1.04 (0.90,1.19)	0.92 (0.79,1.06)	0.97 (0.84,1.12)	1.06 (0.93,1.22)
Individual-level social capital				
Frequency of socializing [#]				
Low	1	1	1	1
High	1.19 (1.00,1.42)	1.14* (1.00,1.31)	1.29*** (1.14,1.46)	1.36*** (1.17,1.59)
Civic participation				
No	1	1	1	1
Yes	0.96 (0.85,1.08)	0.95 (0.84,1.07)	1.10 (0.95,1.27)	0.93 (0.81,1.08)
Trust				
Low	1	1	1	1
High	1.43*** (1.28,1.59)	1.40*** (1.24,1.57)	1.27*** (1.12,1.46)	1.34*** (1.20,1.49)
Community-level social capital				
Frequency of socializing (%)	0.99 (0.97,1.01)	1.01* (1.00,1.02)	1.00 (0.99,1.01)	1.01* (1.00,1.03)
Civic participation (%)	1.01 (1.00,1.01)	1.01 (1.00,1.02)	1.00 (0.99,1.01)	1.00 (0.99,1.01)
Trust (%)	0.98* (0.97,1.00)	1.01* (1.00,1.02)	1.00 (0.98,1.02)	1.00 (0.99,1.02)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130
<i>ICC</i>	0.064	0.055	0.100	0.053

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] p = 0.053 in 2010

Supplementary Table 10. Sensitivity analysis on associations of individual-level and community-level social capital with physical health, 2010-2015 (Two-level ordinal logistic model)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.31*** (1.22,1.41)	1.38*** (1.29,1.49)	1.25*** (1.16,1.34)	1.29*** (1.20,1.39)
Age	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)
Ethnicity				
Non-Han	1	1	1	1
Han	0.89 (0.76,1.05)	1.01 (0.86,1.19)	0.94 (0.80,1.12)	1.08 (0.90,1.28)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.00 (0.91,1.10)	0.96 (0.88,1.05)	1.00 (0.91,1.10)	0.94 (0.86,1.03)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.31*** (1.19,1.45)	1.22*** (1.11,1.35)	1.29*** (1.17,1.43)	1.19*** (1.07,1.31)
Senior secondary school or equal	1.43*** (1.27,1.61)	1.39*** (1.23,1.56)	1.52*** (1.35,1.71)	1.44*** (1.27,1.62)
College or above	1.36*** (1.17,1.57)	1.44*** (1.25,1.66)	1.45*** (1.26,1.68)	1.43*** (1.23,1.66)
Poverty				
Poor	1	1	1	1
Non-poor	1.85*** (1.64,2.09)	1.70*** (1.53,1.90)	1.82*** (1.63,2.04)	1.66*** (1.49,1.85)
Do not know income	1.76*** (1.47,2.11)	1.54*** (1.30,1.81)	1.61*** (1.37,1.90)	1.36** (1.13,1.64)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.95 (0.83,1.08)	0.97 (0.85,1.10)	0.99 (0.87,1.12)	1.05 (0.91,1.22)
Skill level 1	1.11 (0.89,1.39)	1.06 (0.84,1.35)	1.08 (0.86,1.35)	0.99 (0.79,1.24)
Non-employed	0.70*** (0.61,0.81)	0.79*** (0.69,0.90)	0.76*** (0.66,0.87)	0.84* (0.73,0.98)
Place of residence				

Rural	1	1	1	1
Urban	1.14**	1.20***	1.22***	1.36***
	(1.03,1.26)	(1.09,1.32)	(1.11,1.34)	(1.23,1.50)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.40***	1.35***	1.29***	1.35***
	(1.28,1.53)	(1.25,1.47)	(1.18,1.40)	(1.24,1.46)
Civic participation				
No	1	1	1	1
Yes	0.96	1.05	1.03	1.04
	(0.89,1.04)	(0.97,1.13)	(0.95,1.11)	(0.96,1.13)
Trust [#]				
Low	1	1	1	1
High	1.24***	1.23***	1.19***	1.28***
	(1.15,1.33)	(1.14,1.33)	(1.11,1.28)	(1.19,1.39)
Community-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.01*	1.01*
	(0.98,1.01)	(0.99,1.01)	(1.00,1.02)	(1.00,1.02)
Civic participation (%)				
	1.00	1.00	0.99	1.00
	(0.99,1.01)	(0.99,1.00)	(0.98,1.00)	(0.99,1.00)
Trust (%)				
	1.00	1.01	1.00	1.01
	(0.99,1.01)	(1.00,1.02)	(0.99,1.01)	(1.00,1.02)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

Supplementary Table 11. Sensitivity analysis on associations of individual-level and community-level social capital with mental health, 2010-2015 (Two-level ordinal logistic model)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.23*** (1.14,1.32)	1.37*** (1.27,1.47)	1.17*** (1.09,1.26)	1.23*** (1.14,1.32)
Age				
	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)
Ethnicity				
Non-Han	1	1	1	1
Han	0.81* (0.69,0.96)	0.90 (0.76,1.07)	0.94 (0.79,1.11)	0.95 (0.80,1.14)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.23*** (1.12,1.35)	1.23*** (1.12,1.34)	1.21*** (1.10,1.33)	1.14** (1.04,1.25)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.35*** (1.22,1.49)	1.23*** (1.11,1.35)	1.24*** (1.12,1.37)	1.31*** (1.19,1.45)
Senior secondary school or equal	1.42*** (1.27,1.60)	1.49*** (1.33,1.68)	1.38*** (1.22,1.56)	1.51*** (1.34,1.71)
College or above	1.42*** (1.22,1.64)	1.50*** (1.30,1.74)	1.47*** (1.26,1.70)	1.62*** (1.39,1.89)
Poverty				
Poor	1	1	1	1
Non-poor	1.79*** (1.60,2.01)	1.70*** (1.53,1.89)	1.65*** (1.47,1.84)	1.56*** (1.40,1.73)
Do not know income	1.94*** (1.62,2.31)	1.57*** (1.34,1.85)	1.38*** (1.17,1.63)	1.40*** (1.16,1.68)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	1.06 (0.93,1.22)	1.05 (0.92,1.19)	1.06 (0.93,1.22)	1.11 (0.96,1.28)
Skill level 1	1.19 (0.95,1.49)	1.06 (0.84,1.34)	0.99 (0.79,1.24)	1.03 (0.82,1.29)
Non-employed	0.96 (0.83,1.11)	1.11 (0.98,1.27)	1.03 (0.89,1.18)	1.07 (0.92,1.24)
Place of residence				

Rural	1	1	1	1
Urban	1.11*	1.03	1.10	1.19***
	(1.01,1.22)	(0.93,1.13)	(0.99,1.21)	(1.08,1.31)
Individual-level social capital				
Frequency of socializing [#]				
Low	1	1	1	1
High	1.21***	1.20***	1.22***	1.28***
	(1.11,1.32)	(1.11,1.30)	(1.12,1.33)	(1.18,1.40)
Civic participation				
No	1	1	1	1
Yes	0.97	1.04	1.12**	1.06
	(0.90,1.05)	(0.96,1.12)	(1.04,1.22)	(0.98,1.15)
Trust				
Low	1	1	1	1
High	1.36***	1.32***	1.35***	1.35***
	(1.26,1.47)	(1.22,1.42)	(1.25,1.45)	(1.25,1.46)
Community-level social capital				
Frequency of socializing (%)				
	1.00	1.00	1.01	1.00
	(0.99,1.02)	(0.99,1.01)	(0.99,1.02)	(0.99,1.01)
Civic participation (%)				
	1.01	1.01*	1.00	1.01
	(1.00,1.01)	(1.00,1.02)	(0.99,1.01)	(1.00,1.01)
Trust (%)				
	0.99	1.00	0.99	1.00
	(0.98,1.00)	(1.00,1.01)	(0.98,1.00)	(0.99,1.01)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of communities</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

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

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	5
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	6
		(d) If applicable, describe analytical methods taking account of sampling strategy	not applicable
		(e) Describe any sensitivity analyses	
Results			
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	6
		(b) Give reasons for non-participation at each stage	not applicable
		(c) Consider use of a flow diagram	not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7

		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	7
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	not applicable
		(b) Report category boundaries when continuous variables were categorized	5-6
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
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	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
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	11

*Give information separately for exposed and unexposed groups.

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.

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Are Both Individual- and County-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

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Are Both Individual- and County-level Social Capital Associated with Individual Health? A Serial Cross-Sectional Analysis in China, 2010-2015

ABSTRACT

Objectives We aimed to examine the associations of both individual- and county-level social capital with individual health in China during a period of rapid economic growth.

Design and setting: A serial cross-sectional study in China.

Participants and methods The participants were 42,829 Chinese adults (age ≥ 18 years) from the 2010, 2012, 2013, and 2015 Chinese General Social Survey. The outcomes were self-rated physical and mental health in all time points. We assessed social capital by individual- and county-level indicators, including frequency of socializing, civic participation, and trust. We conducted multilevel binary logistic regression models to examine the associations of individual- and county-level social capital with self-rated physical and mental health.

Results At the individual level, high frequency of socializing (2010: OR 1.49, 95%CI 1.33 to 1.66; 2012: OR 1.39, 95%CI 1.26 to 1.54; 2013: OR 1.28, 95%CI 1.15 to 1.42; 2015: OR 1.36, 95%CI 1.23 to 1.50) and high trust (2010: OR 1.34, 95%CI 1.22 to 1.47; 2012: OR 1.30, 95%CI 1.18 to 1.42; 2013: OR 1.21, 95%CI 1.10 to 1.33; 2015: OR 1.41, 95%CI 1.28 to 1.55) were significantly associated with good physical health in all years. At the individual level, high frequency of socializing (2010: OR 1.27, 95%CI 1.14 to 1.42; 2012: OR 1.21, 95%CI 1.09 to 1.34; 2013: OR 1.30, 95%CI 1.17 to 1.45; 2015: OR 1.35, 95%CI 1.22 to 1.50) and high trust (2010: OR 1.47, 95%CI 1.34 to 1.61; 2012: OR 1.42, 95%CI 1.30 to 1.56; 2013: OR 1.36, 95%CI 1.24 to 1.49; 2015: OR 1.43, 95%CI 1.30 to 1.57) were also significantly associated with good mental health in all years. No evidence showed that the associations of individual-level frequency of socializing and trust with physical and mental health changed over time. There were no consistent associations of individual-level civic participation or any county-level social capital indicators with physical or mental health.

Conclusion The positive associations of individual-level social capital in terms of socializing and trust with physical and mental health were robust during a period of rapid economic growth. Improving individual-level socializing and trust for health promotion could be a long-term strategy even within a rapidly developing society.

Strengths and limitations of this study

- A major strength of our study is the comparability of the associations between multilevel social capital and health outcomes over time. Hence, our consistent findings provided more solid evidence for associations of the individual-level frequency of socializing and trust with physical and mental health beyond previous mixed results.
- We took advantage of a rapidly developing society (i.e., China) as a social laboratory to observe the associations between multilevel social capital and health outcomes.
- We cannot make causal inferences since this study is cross-sectional by nature.
- We only included generalized trust in cognitive social capital. This measurement may not directly capture county-specific trust.
- The study period was relatively short (i.e., six years), which prohibited us from observing a longer trend of the association.

INTRODUCTION

Social capital, defined as resources available to members of social groups and resources embedded within an individual's social networks,^{1,2} is a critical social determinant in shaping population health. Although debates are ongoing as to whether social capital is an individual attribute or a collective property, previous public health studies suggested that the individual and collective perspectives were not mutually exclusive and might affect individuals' health simultaneously.^{3,4} From an individual perspective, social capital affects health by providing informational, emotional, and instrumental support. From a collective perspective, social capital affects health by facilitating collective action, maintaining social norms, and enhancing reciprocity.^{5,6}

The association between multilevel social capital and health

An increasing number of studies employed a multilevel analytical framework to examine the associations of both individual- and collective-level social capital with health. Nevertheless, results from these multilevel studies were mixed.^{3,7-10} Most of these studies found that at least one indicator of each level of social capital was associated with health. Some studies only showed an association between individual-level social capital and health, while a handful of studies suggested that only collective-level social capital was associated with health. Although most of these studies indicated that social capital was beneficial for health, several studies reported negative associations between social capital and health.¹¹⁻¹³ Even studies within the same countries (e.g., Japan^{12,14} and China^{13,15}) showed inconsistent results in terms of the directions of the associations between social capital and health.

The above-mentioned inconsistent results may be due to different operationalizations of social capital, different study time points, or both. Although different operationalizations of social capital provided insights to understand what specific social capital indicator was beneficial for health among a spectrum of social capital measures, they made it difficult to make meaningful comparisons between studies and to examine whether the association between social capital and health was consistent over time. To our knowledge, only at the individual level did previous studies examine whether the association between social capital and health changed over time. For example, a Chinese study indicated that the association between individual-level social capital and health varied with periods,¹⁶ while a newly published study in Montreal, Canada showed a longitudinal association between individual-level social capital and health.¹⁷ Nevertheless, little is known as to whether the association between multilevel social capital and health changed over time. Hence, it is unclear whether improving social capital could be considered a long-term health promotion strategy.

Theoretical hypotheses

It is theoretically debatable whether the association between multilevel social capital and health changed over time, especially with rapid economic growth. On the one hand, it is argued that economic growth may erode social capital as it can extend market relationships to people's noneconomic life.¹⁸ With economic growth, the time available for people's social activities may also reduce, leading to a reduction in social capital. As found in the United States, social capital decreased continuously despite the growing economy.¹⁹ Hence, people's health may depend less on social capital as economy grows, and they can receive health benefits directly from economic growth. In other words, it can be hypothesized that the strength of the association between social capital and health may decline as economy grows.

On the other hand, it is also argued that social capital may still be important for people's health during rapid economic development. Rapid economic growth often co-exists with social change; thus, formal institutions may not be well established in a rapidly developing society, and people may need to rely on informal institutions, which encompasses the concepts of norms of behavior and social conventions that significantly overlap with the notion of social capital.²⁰ Also, social change may lead to social uncertainties; in other words, social capital is

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3 important for obtaining information and support from others to address these uncertainties.²¹ For instance, a
4 Chinese study found that social capital could reduce suicide ideation by reducing uncertainty stress.²² In this light,
5 it can be hypothesized that the strength of the association between social capital and health does not vary
6 significantly over time with economic growth.
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10 **Study setting and research questions**

11 China is an ideal setting to examine whether the association of social capital with health changed during a period
12 of rapid economic growth. China has experienced rapid economic development over the past four decades. Its
13 gross domestic product (GDP) increased rapidly from 1.8% of the global economy in 1978 to 15% in 2018.²³ This
14 rapid economic transition allows us to use a relatively short period to observe whether the association between
15 multilevel social capital and health changed with socioeconomic development. It also allows us to compare the
16 difference in the change of association of multilevel social capital with health between the traditionally long-term
17 developed western societies and those with more recent and rapid economic development. Additionally, China is
18 also characterized by its traditional culture of relationship traceable back to Confucian ethics.²⁴ Collectivistic
19 culture in China institutionalizes the legitimacy of individuals' dependence on social networks.²⁵ This distinction
20 of the Chinese culture from other western societies, where individualistic culture generally facilitates
21 independence from each other,²⁶ may give us further insights into the association between social capital and health
22 that may be overlooked previously.
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26 We specifically examined: (1) how individual-level social capital, county-level social capital, and health
27 changed during a period of rapid economic growth; (2) what the associations of individual- and county-level social
28 capital with health were in each survey year; and (3) whether the associations changed during a period of rapid
29 economic growth.
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33 **METHODS**

34 **Data source and participants**

35 We collected data from the 2010, 2012, 2013, and 2015 waves of the Chinese General Social Survey (CGSS),
36 which is publicly available. The participants were Chinese adults aged 18 years or above. Health outcomes, social
37 capital, sociodemographic, and socioeconomic factors were consistently collected throughout the four years. The
38 CGSS is a national representative survey project in Mainland China conducted by the Renmin University of China.
39 The sampling strategy was described in further details in a previous study.¹³
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44 **Measurements**

45 **Health outcomes**

46 Health outcomes were self-rated physical and mental health. For physical health, respondents answered the
47 question "How do you think about your current physical health?" Responses were divided into "poor" (including
48 "very unhealthy", "unhealthy", and "neutral") and "good" (including "healthy" and "very healthy") physical
49 health. For mental health, respondents answered the question "During the past four weeks, how often have you
50 felt depressed or downhearted?" This question is taken from the 12-item Short-Form Health Survey.²⁷ Responses
51 were categorized into "poor" (including "always", "often", and "sometimes") and "good" (including "seldom"
52 and "never") mental health. The two self-rated health indicators were used in previous studies.²⁸⁻³⁰
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Social capital

Social capital can be separated into structural and cognitive dimensions. Structural social capital refers to actual network connections and civic engagement, while cognitive social capital refers to perceptions of trust and norms.³ We measured individual-level structural social capital by respondents' frequency of socializing (high, low) and civic participation (yes, no). We measured individual-level cognitive social capital by respondents' trust of others (high, low). Details of the questions are shown in Supplementary Material 1.

We calculated county-level social capital by using individual-level social capital variables. Counties are the primary sampling units in CGSS.¹³ On average, each county included 81 respondents in 2010, 85 in 2012, 85 in 2013, and 79 in 2015. Following previous studies,^{31–33} we conducted two-level random intercept logistic regressions to calculate county-level social capital, with individuals as Level 1 and counties as Level 2. We treated each of the three above-mentioned individual-level social capital variables as a dependent variable. We calculated county-level social capital by adding the grand mean of county social capital to the residuals at the county level. Details are shown in Supplementary Material 2. Higher percentages indicated higher county-level social capital.

Sociodemographic and socioeconomic factors

We included gender (male, female), age (years), ethnicity (*Han*, non-*Han*), and marital status (married/cohabitation, never married/divorced/separated/widowed) as sociodemographic factors, and education (primary school or below, junior secondary school, senior secondary school, and college or above), occupation, poverty, and places of residence (rural, urban) as socioeconomic factors. There are 56 ethnic groups in China and *Han* is the majority. The heterogeneity across ethnic groups in terms of socioeconomic experience and culture may affect both people's health and social capital.³⁴ Thus, we controlled for ethnicity in our study. Details of the occupation and poverty are shown in Supplementary Material 3.

Statistical analysis

We reported weighted means with standard deviations (SD) for continuous variables and weighted percentages for categorical variables. We calculated individual weighting factors by the distribution of gender, age, and place of residence according to the 2010 China population census data,³⁵ and county weighting factors according to the distribution of the numbers of counties in each province in 2010 based on the China Statistical Yearbook 2011.³⁶ To examine how social capital and health changed over time, following the methodology in previous studies,^{37,38} we assessed the trends of health and individual-level social capital by conducting binary logistic regression models with calendar year as the independent variable. The results of the regressions indicated whether the health variations and the individual-level social capital variations between years were statistically significant. Similarly, with calendar year as the independent variable, we assessed the trends of county-level social capital by linear regression models. Years were treated as fixed effects in the above-mentioned models.

To examine the associations of individual- and county-level social capital with health, we employed two-level binary logistic regression models adjusting for sociodemographic and socioeconomic factors. The two levels specified in our models were: individuals at Level 1 nested within counties at Level 2. The intercepts at the county level were treated as random. We compared the results of regression models with weighted and unweighted data for robustness check. The weighting method is shown in Supplementary Material 4. We also treated physical and mental health as ordinal variables and conducted two-level ordinal regression models for robustness check. To examine whether the associations of social capital with physical and mental health changed over time, we performed interaction tests between social capital indicators and survey year. Following previous studies,^{39,40} we

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3 tested the significance of interaction terms by adding each interaction term, one at a time, to the full models.

4 We used Stata/MP 14.2 to conduct all data analysis with a two-tailed p -value < 0.05 as the significance level.

7 **Patient and public involvement**

8 All data in this study were derived from the CGSS dataset. No patients and the public were involved in the
9 design or planning of this study.

12 **RESULTS**

13 Our study included a total of 42,829 respondents. Specifically, there were 10,827 respondents nested in 133
14 counties in 2010, 11,104 in 131 counties in 2012, 10,663 in 126 counties in 2013, and 10,235 in 130 counties in
15 2015. Table 1 presents the weighted sample characteristics in 2010, 2012, 2013, and 2015; the missing data values
16 are listed in online supplementary table 1; and the unweighted results are shown in online supplementary table 2.
17 Generally, the percentages of good physical and mental health fluctuated over the study period, but both the
18 percentages were lowest in 2012 and peaked in 2013. For individual-level social capital, high frequency of
19 socializing increased generally and peaked in 2013; civic participation peaked in 2012 and reached the lowest
20 level in 2013; high trust decreased to the bottom in 2013 and then slightly rebounded in 2015. For county-level
21 social capital, the percentage of high frequency of socializing increased; the percentage of civic participation
22 decreased and dropped to the bottom in 2013; the percentage of trust decreased from 2010 to 2013 and then
23 increased in 2015.

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28 *[Table 1 here]*

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30 Figure 1 shows the trends of physical and mental health, individual-level social capital, and county-level
31 social capital over time. Figure 1a indicates that the likelihood of good physical health in 2012 (odds ratio (OR)
32 0.95, 95% confidence interval (CI) 0.89–1.00) was marginal-significantly ($p = 0.062$) lower than that in 2010
33 (reference). However, this likelihood in 2013 (OR 1.31, 95% CI 1.24–1.40) and 2015 (OR 1.21, 95%CI 1.13–
34 1.28) was significantly higher than that in 2010. The likelihood of good mental health in 2013 (OR 1.30, 95%CI
35 1.22–1.38) and 2015 (OR 1.13, 95%CI 1.06–1.21) was also significantly higher than that in 2010. No significant
36 difference in mental health was observed between 2010 and 2012.

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38 Figure 1b shows that the likelihood of high frequency of socializing in 2012 (OR 1.28, 95%CI 1.19–1.37),
39 2013 (OR 1.34, 95%CI 1.25–1.43), and 2015 (OR 1.31, 95%CI 1.22–1.41) was significantly higher than that in
40 2010. The likelihood of civic participation in 2012 (OR 1.07, 95%CI 1.01–1.14) was significantly higher than that
41 in 2010. However, it decreased and became significantly lower in 2013 (OR 0.90, 95%CI 0.84–0.95) than that in
42 2010. No evidence showed that the likelihood of civic participation in 2015 was significantly different from that
43 in 2010. The likelihood of high trust in 2012 (OR 0.92, 95%CI 0.87–0.98), 2013 (OR 0.67, 95%CI 0.63–0.71),
44 and 2015 (OR 0.90, 95%CI 0.84–0.96) was significantly lower than that in 2010.

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4 Figure 1c shows that county-level frequency of socializing in 2012 ($\beta = 12.91$, 95%CI 10.52–15.29), 2013
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6 ($\beta = 16.28$, 95%CI 13.76–18.79), and 2015 ($\beta = 21.30$, 95%CI 18.95–23.66) was significantly higher than that in
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8 2010. County-level civic participation in 2012 ($\beta = -3.59$, 95%CI -6.92– -0.26), 2013 ($\beta = -6.87$, 95%CI -10.21–
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10 -3.53), and 2015 ($\beta = -3.59$, 95%CI -7.00– -0.17) was significantly lower than that in 2010. County-level trust in
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12 2013 ($\beta = -4.32$, 95%CI -6.72– -1.93) and 2015 ($\beta = -3.32$, 95%CI -5.21– -1.44) was significantly lower than that
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14 in 2010. No evidence showed that county-level trust in 2012 was significantly different from that in 2010.
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19 *[Figure 1 here]*

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21 Table 2 shows the associations of both individual- and county-level social capital with physical health.
22 Among the individual-level social capital indicators, high frequency of socializing (2010: OR 1.49, 95%CI 1.33–
23 1.66; 2012: OR 1.39, 95%CI 1.26–1.54; 2013: OR 1.28, 95%CI 1.15–1.42; 2015: OR 1.36, 95%CI 1.23–1.50)
24 and high trust (2010: OR 1.34, 95%CI 1.22–1.47; 2012: OR 1.30, 95%CI 1.18–1.42; 2013: OR 1.21, 95%CI 1.10–
25 1.33; 2015: OR 1.41, 95%CI 1.28–1.55) were significantly associated with good physical health in all years. No
26 evidence supported that there was a significant association between civic participation and physical health after
27 adjustment in any year. Among county-level social capital indicators, after adjustments, higher percentages of
28 frequency of socializing was significantly positively associated with good physical health in 2015 (OR 1.01,
29 95%CI 1.00–1.02). In contrast, a higher percentage of civic participation was significantly negatively associated
30 with good physical health in 2015 (OR 0.99, 95%CI 0.98–1.00); nevertheless, the ORs were close to one.
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38 Table 3 presents the associations of both individual- and county-level social capital with mental health. The
39 associations were similar to that of social capital with physical health in terms of directions and significance.
40 Among individual-level social capital indicators, high frequency of socializing (2010: OR 1.27, 95%CI 1.14–
41 1.42; 2012: OR 1.21, 95%CI 1.09–1.34; 2013: OR 1.30, 95%CI 1.17–1.45; 2015: OR 1.35, 95%CI 1.22–1.50)
42 and high trust (2010: OR 1.47, 95%CI 1.34–1.61; 2012: OR 1.42, 95%CI 1.30–1.56; 2013: OR 1.36, 95%CI 1.24–
43 1.49; 2015: OR 1.43, 95%CI 1.30–1.57) were significantly associated with good mental health. Civic participation
44 was only positively associated with good mental health in 2013 (OR 1.17, 95%CI 1.05–1.29). No significant
45 association between any county-level social capital indicator and mental health in the four years was observed.
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49 The intraclass correlations (ICCs) ranged from 0.052 to 0.107 for physical health (Table 2) and ranged from
50 0.060 to 0.125 for mental health (Table 3) in each year; in other words, 5.2% to 10.7% of the total variance in
51 physical health and 6.0% to 12.5% of the total variance in mental health occurred at the county level.
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54 *[Table 3 here]*

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56 As for sociodemographic and socioeconomic factors, being male, non-poor, and having a higher education
57 level were significantly associated with good physical and mental health in all years. Being older was negatively
58 associated with good physical and mental health in all years. Additionally, being non-employed was significantly
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3 associated with a lower likelihood of having good physical health comparing with having occupations at Skill
4 level 3 or 4 (reference) in all years, but not significantly associated with mental health. Being married or cohabiting
5 was significantly associated with good mental health in all years, but not associated with physical health.
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7 The results stratified by place of residence (i.e., rural and urban) showed similar patterns to the results from
8 the whole sample in each year in terms of the associations of individual-level frequency of socializing and trust
9 with physical and mental health (online supplementary table 3 and 4). The results from the pooled data between
10 2010 and 2015 also showed that individual-level social capital in terms of frequency of socializing and trust was
11 associated with physical and mental health after adjustment (online supplementary table 5).
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13 We further examined the interactions between social capital indicators and survey year (online
14 supplementary table 6 and table 7). For physical health, the interaction effect between county-level frequency of
15 socializing and year (High frequency of socializing \times 2015: OR 1.02, 95%CI 1.01-1.03), and the interaction effect
16 between county-level civic participation and year (Civic participation (Yes) \times 2012: OR 0.99, 95%CI 0.99-1.00)
17 were significant. For mental health, the interaction effect between county-level frequency of socializing and year
18 (High frequency of socializing \times 2015: OR 1.02, 95%CI 1.01-1.03), the interaction effect between county-level
19 civic participation and year (Civic participation (Yes) \times 2013: OR 0.99, 95%CI 0.99-1.00), and the interaction
20 effect between county-level trust and year (High trust \times 2012: OR 1.01, 95%CI 1.01-1.02; High trust \times 2013: OR
21 1.01, 95%CI 1.00-1.02) were significant. Nevertheless, the ORs for both physical and mental health were close
22 to one.
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24 We repeated the two-level binary regression models based on the whole weighted sample of each year (i.e.,
25 Table 2 and Table 3). The associations between both levels of social capital and health outcomes (online
26 supplementary table 8 and 9) were similar to our unweighted results in Table 2 and Table 3. We also conducted
27 sensitivity analyses by treating physical and mental health as ordinal variables. The associations between both
28 levels of social capital and health outcomes (online supplementary table 10 and 11) were consistent with our
29 previous results as presented in Table 2 and Table 3.
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32 **DISCUSSION**

33 **Main findings**

34 To our knowledge, this is the first serial cross-sectional study in China examining the associations of multilevel
35 social capital with individuals' physical and mental health with nationally representative data. We found that the
36 likelihood of having good physical and mental health fluctuated during a period of rapid economic development;
37 in other words, the likelihood of having good physical and mental health did not consistently increase with
38 economic growth during this study period. Among the indicators of individual-level social capital, in general, the
39 likelihood of high frequency of socializing increased, the likelihood of civic participation fluctuated, and the
40 likelihood of high trust decreased during the survey period. Among the indicators of county-level social capital,
41 in general, the percentage of high frequency of socializing increased, the percentage of civic participation and the
42 percentage of high trust decreased. We also found that higher levels of individual-level social capital in terms of
43 frequency of socializing and trust were consistently associated with good physical and mental health during the
44 period of rapid economic development. However, we did not find evidence for a consistent association of any
45 county-level social capital indicator with physical or mental health during the same period.
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55 **Interpretations**

56 Putting the results together, our study suggests that no matter how people's physical and mental health changed
57 during a period of rapid economic growth, individual-level social capital in terms of socializing and trust
58 consistently played a pivotal role in protecting individuals' physical and mental health. Therefore, we should
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3 especially pay attention to improve people's trust for health promotion purpose, and that the decreased individual-
4 level trust within the observed period should be of concern.
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6 The provision of informational, instrumental, and emotional support may be plausible reasons why the
7 individual-level frequency of socializing was associated with our health outcomes.^{6,41} Socializing helps maintain
8 and extend individuals' social networks, from which individuals can obtain monetary, material and mental
9 assistance, and health-rated information. Additionally, a higher frequency of socializing is beneficial for mental
10 health by fulfilling the human need for social connectedness, increasing people's sense of belonging, and reducing
11 the perceived isolation.⁴² Moreover, people with high trust are more likely to consider healthcare systems and
12 health-related information as trustful social resources,^{43,44} and more likely to perceive emotional support.⁴⁵ They
13 also have less sense of social anxiety.⁴⁶

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16 We argue that some of the mechanisms above may have little changes in a rapidly developing society,
17 resulting in the observed consistent associations of individual-level socializing and trust with physical and mental
18 health. First, a rapidly developing economy is almost always accompanied by social change. Under such
19 circumstances, the formally established health-related institutions and information channels may not fulfill
20 people's needs while the new ones may not be completely established or may not operate steadily. Hence, people
21 need to obtain support from informal channels, such as family members, friends, and acquaintances. Second, a
22 rapidly developing society is often accompanied by technological innovation and information explosion. An
23 individual is almost unlikely to know everything about new health-related technology and information on his or
24 her own. In this light, socializing could reduce individuals' costs to learn new health-related technology and obtain
25 new information through social networks. Also, people with high trust may be more likely to consider emerging
26 health-related institutions, technology, and information in a rapidly developing society as trustworthy, and are
27 thus more willing to use them. An example is online prescription drug services. A study in the United States found
28 that people with higher trust had greater intention of adopting online prescription drug services.⁴⁷ However, more
29 study is needed to examine whether this is also the case in China, as the radius of trust is different between China
30 and the US, where Chinese are more prone to consider general trust as trust in strong ties, while Americans as
31 trust in weak ties.⁴⁸ Additionally, a rapidly developing society may also be accompanied by high social mobility
32 and great social uncertainty, whereby people do not have enough information to predict others' behaviors.²¹ In
33 such situation, people with a high trust of others are less likely to worry about others' intention to harm them;
34 hence, they might suffer from less anxiety.
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41 On the other hand, we did not find consistent associations of individual-level civic participation with physical
42 and mental health. Previous studies showed mixed associations between individual-level civic participation and
43 health outcomes.^{45,49,50} We measured civic participation by voting in the neighborhood/village committee election.
44 Previous studies argued that local political participation (e.g., voting) could affect welfare policies provided by
45 governments.^{51,52} Nevertheless, neighborhood/village committees in China have no right to make policies.
46 Additionally, voting is a social- and political-specific indicator for civic participation, and may have different
47 connotations in different contexts, thereby resulting in inconsistent associations between civic participation and
48 health in different societies.
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51 We also did not find consistent associations of any county-level social capital indicators with physical or
52 mental health. Previous studies showed mixed results as to the associations between collective-level social capital
53 and health.^{45,49,50,53} The mixed results may be due to different geographic scales where study areas were located.
54 For example, studies in the UK defined collective-levels as post-code sectors,^{50,54} while studies in the US measured
55 collective-level social capital at the state level.^{51,55} While a previous Chinese study measured collective-level
56 social capital at the village level,⁴⁵ the present study measured collective-level social capital at the county level.
57 Also, the social capital indicators in these studies were not the same; hence, it is difficult to make straightforward
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3 comparisons with other studies.

4 It should be noticed that our social capital indicators are not exactly the same as in the previous Chinese
5 studies.^{13,49,56–59} The definition of social capital is still debatable and there is no single best measure of social
6 capital.² As we intended to make comparisons across years, we only used the variables which were collected in
7 all the survey years. In previous studies, one of the approaches on social capital measurement is “Position
8 Generator,”⁶⁰ and several Chinese studies found associations between social capital and health outcomes using
9 the “Position Generator”.^{58,59,61} Other previous Chinese studies also employed multiple items and combined the
10 items as social capital indexes,^{13,16,62–66} while some studies employed different single items as different dimensions
11 of social capital (e.g. studies used social relationship⁶⁷ and organization membership^{49,68,69} as structural social
12 capital, and trust as cognitive social capital.^{61,67,70}) Trust is the most common measurement of social capital
13 shown to be associated with different health outcomes, which was consistent with our results. However, we used
14 frequency of socializing and voting behavior as structural social capital, which were not commonly used in
15 previous studies. The difference in measurements should be taken into account when comparing our results with
16 results in other studies.
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23 **Strengths and limitations**

24 A major strength of our study is the comparability of the associations between multilevel social capital and health
25 outcomes over time. Our consistent findings provided more solid evidence for associations of the individual-level
26 frequency of socializing and trust with physical and mental health beyond previous mixed results. Another
27 strength is that we took advantage of a rapidly developing society (i.e., China) as a social laboratory to observe
28 the associations between multilevel social capital and health outcomes.
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30 A limitation of our study is that we cannot make causal inferences since this study is cross-sectional by
31 nature. However, our health outcomes were “current” physical health and mental health in the “past four weeks”,
32 and our frequency of socializing was socializing “in the past year”. The timeline helped us partially avoid reverse
33 associations between individual-level frequency of socializing and health outcomes. Secondly, we only included
34 generalized trust in cognitive social capital. While this measurement cannot directly capture county-specific trust
35 (e.g. trust in neighbors), it was used in previous studies.^{50,53,55,71} Thirdly, the study period was relatively short (i.e.,
36 six years), which prohibited us from observing a more long-term trend of the association. However, as we
37 observed the association in a rapidly developing and changing society and the development and changes are
38 ongoing, we speculate that the associations we observed will remain in the long run. Fourthly, the two single-item
39 questions on measuring physical and mental health may be subject to validity and reliability issues. As compared
40 with multiple-item scales, the measurement errors of single-item questions may be higher. Nevertheless, previous
41 studies found that self-rated health was a predictor for mortality.⁷² Further studies using established instruments
42 to assess physical and mental health are needed. Last but not least, we could not estimate the independent causal
43 effect of county-level social capital on individuals’ health. We used multilevel regression models instead of
44 aggregating individual-level responses to estimate the county-level social capital, taking individual characteristics
45 into account. However, we could not adjust for all individual characteristics in the models. Further studies using
46 other study designs, such as natural experiments or randomized community trials, are needed.
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54 **Conclusion**

55 Our findings suggest that individual-level social capital in terms of frequency of socializing and trust is a robust
56 social determinant of health during a period of rapid economic growth. Hence, improving individual-level social
57 capital for health promotion could be a long-term strategy even in a rapidly developing society. Interventions can
58 be designed to increase opportunities for socializing and to improve trust. Given that people with less socializing
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3 and lower trust appear to be at a higher risk of poor health, interventions could consider a population segmentation
4 strategy based on social capital indicators to target individuals with lower frequency of socializing and lower trust.
5 It may be difficult for policies to target individuals directly, but they can be designed as a “nudge” for individuals’
6 socializing and trust. For example, governments can consider providing freely accessible public space (e.g., parks,
7 activity centers) for people’s social interaction, and they can also extend operation hours of public transports to
8 encourage socialization. Trustworthy and transparent health-related information channels should also be
9 established. On the other hand, policymakers may pay attention to avoid damaging social capital when
10 implementing other policies.
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16 **Contributors** YH was responsible for literature review, study design, data analysis, data interpretation, and
17 drafting the manuscript. RYC oversaw the whole study and was responsible for literature review, study design,
18 data interpretation and write-up of the manuscript.
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25 China for collecting and releasing the data
26
27

28 **Competing interests** We declare no competing interests.
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30 **Patient and public involvement** Patients and/or the public were not involved in this research.
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33 **Patient consent for publication** Not required.
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36 **Ethics approval** No ethics review was needed for these secondary analyses of publicly available, anonymized
37 data
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40 **Data availability statement** The secondary data are available from Chinese National Survey Data Archive.
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Table 1. Sample Characteristics, 2010-2015

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	36.43	37.75	30.36	32.21
Good	63.57	62.25	69.64	67.79
Mental Health				
Poor	32.83	33.03	27.35	30.19
Good	67.17	66.97	72.65	69.81
Sociodemographic factors				
Gender				
Female	49.48	49.48	49.48	49.48
Male	50.52	50.52	50.52	50.52
Age (years)	42.76±16.35	42.76±16.39	42.74±16.36	42.74±16.38
Ethnicity				
Non-Han	9.97	9.82	9.64	8.68
Han	90.03	90.18	90.36	91.32
Marital status				
Single/separated/divorced/widowed	24.16	24.40	25.17	25.78
Cohabit/married	75.84	75.60	74.83	74.22
Socioeconomic factors				
Education				
Primary school or below	33.77	32.50	31.25	29.95
Junior secondary school	31.33	30.04	30.89	30.75
Senior secondary school or equal	19.35	19.85	19.64	19.66
College or above	15.55	17.62	18.22	19.64
Occupation [#]				
Skill 3 or 4	10.62	13.40	11.93	11.88
Skill 2	53.53	51.75	51.15	47.33
Skill 1	3.58	2.71	3.40	4.56
Non-employed	32.27	32.14	33.52	36.22
Poverty				
Poor	11.59	15.23	13.24	14.71
Non-poor	81.08	76.44	77.79	79.76
Do not know income	7.33	8.33	8.97	5.53
Place of residence				
Urban	51.76	51.76	51.76	51.76
Rural	48.24	48.24	48.24	48.24
Social capital				
Frequency of socializing				
Low	77.11	72.51	71.58	71.94

High	22.89	27.49	28.42	28.06
Civic participation				
No	55.78	54.06	58.48	56.44
Yes	44.22	45.94	41.52	43.56
Trust				
Low	35.44	37.34	45.13	37.92
High	64.56	62.66	54.87	62.08
County level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	19.09±6.36	31.99±9.10	35.36±10.99	40.39±9.78
Civic participation (%)	24.62±12.65	21.02±9.79	17.74±9.77	21.03±10.82
Trust (%)	47.71±7.41	46.07±9.88	43.39±9.03	44.39±5.82

Weighted percentages for categorical variables and weighted means for continuous variables with standard deviations

Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations (for more details, please see Supplementary Material 2).

Table 2. Associations of individual- and county-level social capital with physical health, 2010-2015
(Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.31*** (1.20,1.43)	1.30*** (1.19,1.42)	1.20*** (1.09,1.32)	1.31*** (1.19,1.43)
Age				
	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)
Ethnicity				
Non-Han	1	1	1	1
Han	0.89 (0.73,1.09)	1.02 (0.84,1.24)	0.94 (0.77,1.16)	1.08 (0.88,1.33)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.02 (0.90,1.14)	0.90 (0.81,1.01)	1.01 (0.90,1.14)	0.93 (0.83,1.04)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.18** (1.05,1.33)	1.20** (1.07,1.34)	1.27*** (1.13,1.43)	1.12 (1.00,1.26)
Senior secondary school or equal	1.31*** (1.14,1.51)	1.40*** (1.22,1.60)	1.49*** (1.28,1.73)	1.40*** (1.21,1.62)
College or above	1.42*** (1.18,1.70)	1.52*** (1.27,1.81)	1.60*** (1.32,1.94)	1.61*** (1.33,1.95)
Poverty				
Poor	1	1	1	1
Non-poor	1.58*** (1.38,1.82)	1.68*** (1.48,1.90)	1.64*** (1.44,1.87)	1.55*** (1.37,1.76)
Do not know income	1.54*** (1.24,1.93)	1.43*** (1.18,1.74)	1.49*** (1.23,1.81)	1.31* (1.05,1.64)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.89 (0.74,1.07)	0.94 (0.80,1.11)	0.94 (0.78,1.13)	0.96 (0.79,1.17)
Skill level 1	1.19 (0.89,1.58)	1.03 (0.77,1.37)	0.99 (0.74,1.34)	0.87 (0.66,1.16)
Non-employed	0.66*** (0.55,0.80)	0.77** (0.65,0.90)	0.63*** (0.52,0.76)	0.76** (0.63,0.93)
Place of residence				

Rural	1	1	1	1
Urban	1.08	1.13*	1.29***	1.29***
	(0.96,1.21)	(1.01,1.27)	(1.15,1.46)	(1.15,1.45)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.49***	1.39***	1.28***	1.36***
	(1.33,1.66)	(1.26,1.54)	(1.15,1.42)	(1.23,1.50)
Civic participation				
No	1	1	1	1
Yes	1.01	1.01	1.01	0.99
	(0.91,1.11)	(0.92,1.11)	(0.91,1.11)	(0.90,1.10)
Trust				
Low	1	1	1	1
High	1.34***	1.30***	1.21***	1.41***
	(1.22,1.47)	(1.18,1.42)	(1.10,1.33)	(1.28,1.55)
County-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.00	1.01**
	(0.97,1.01)	(0.99,1.01)	(0.99,1.01)	(1.00,1.02)
Civic participation (%)				
	1.00	0.99	0.99	0.99**
	(0.99,1.01)	(0.98,1.00)	(0.98,1.00)	(0.98,1.00)
Trust (%)				
	1.00	1.01	1.01	1.01
	(0.99,1.02)	(1.00,1.02)	(0.99,1.02)	(1.00,1.03)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130
<i>ICC</i>	0.081	0.055	0.107	0.052

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

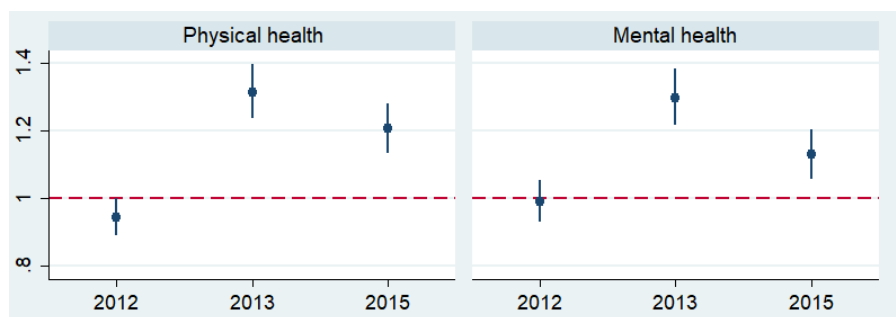
Table 3. Associations of individual- and county-level social capital with mental health, 2010-2015 (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24*** (1.13,1.35)	1.32*** (1.21,1.44)	1.11* (1.01,1.22)	1.25*** (1.14,1.37)
Age				
	0.99*** (0.99,0.99)	0.99*** (0.99,1.00)	0.99*** (0.99,0.99)	0.99*** (0.99,1.00)
Ethnicity				
Non-Han	1	1	1	1
Han	0.87 (0.72,1.06)	1.06 (0.87,1.28)	0.94 (0.77,1.16)	0.99 (0.81,1.23)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.25*** (1.12,1.40)	1.21*** (1.09,1.35)	1.29*** (1.15,1.44)	1.21*** (1.08,1.35)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.35*** (1.20,1.51)	1.24*** (1.11,1.39)	1.23*** (1.09,1.39)	1.28*** (1.13,1.44)
Senior secondary school or equal	1.44*** (1.25,1.66)	1.53*** (1.33,1.76)	1.37*** (1.18,1.59)	1.62*** (1.40,1.88)
College or above	1.58*** (1.32,1.90)	1.51*** (1.27,1.80)	1.51*** (1.25,1.83)	1.71*** (1.42,2.07)
Poverty				
Poor	1	1	1	1
Non-poor	1.80*** (1.58,2.06)	1.77*** (1.57,1.99)	1.77*** (1.56,2.02)	1.54*** (1.36,1.74)
Do not know income	1.88*** (1.52,2.33)	1.55*** (1.28,1.87)	1.36** (1.13,1.65)	1.37** (1.11,1.71)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	1.01 (0.85,1.21)	1.01 (0.86,1.19)	1.03 (0.86,1.23)	1.21 (1.00,1.46)
Skill level 1	1.16 (0.88,1.54)	0.99 (0.75,1.32)	1.04 (0.77,1.40)	1.13 (0.86,1.50)
Non-employed	0.94 (0.79,1.13)	1.04 (0.89,1.23)	0.92 (0.77,1.11)	1.05 (0.87,1.27)
Place of residence				

Rural	1	1	1	1
Urban	1.07	0.99	1.07	1.17**
	(0.96,1.20)	(0.88,1.11)	(0.95,1.21)	(1.04,1.31)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.27***	1.21***	1.30***	1.35***
	(1.14,1.42)	(1.09,1.34)	(1.17,1.45)	(1.22,1.50)
Civic participation				
No	1	1	1	1
Yes	0.98	1.04	1.17**	1.01
	(0.89,1.08)	(0.95,1.14)	(1.05,1.29)	(0.92,1.12)
Trust				
Low	1	1	1	1
High	1.47***	1.42***	1.36***	1.43***
	(1.34,1.61)	(1.30,1.56)	(1.24,1.49)	(1.30,1.57)
County-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.00	1.01
	(0.98,1.01)	(0.99,1.01)	(0.99,1.01)	(1.00,1.02)
Civic participation (%)				
	1.01	1.01	1.00	1.00
	(1.00,1.01)	(1.00,1.02)	(0.98,1.01)	(1.00,1.01)
Trust (%)				
	0.99	1.01	1.00	1.00
	(0.98,1.00)	(1.00,1.02)	(0.98,1.01)	(0.99,1.02)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130
<i>ICC</i>	0.060	0.061	0.125	0.062

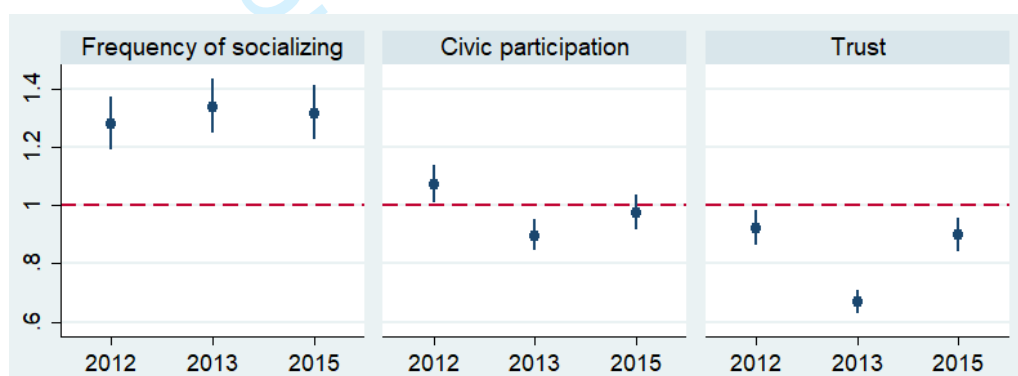
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 1 Trends of health outcomes, individual-level social capital and county-level social capital, 2010-2015



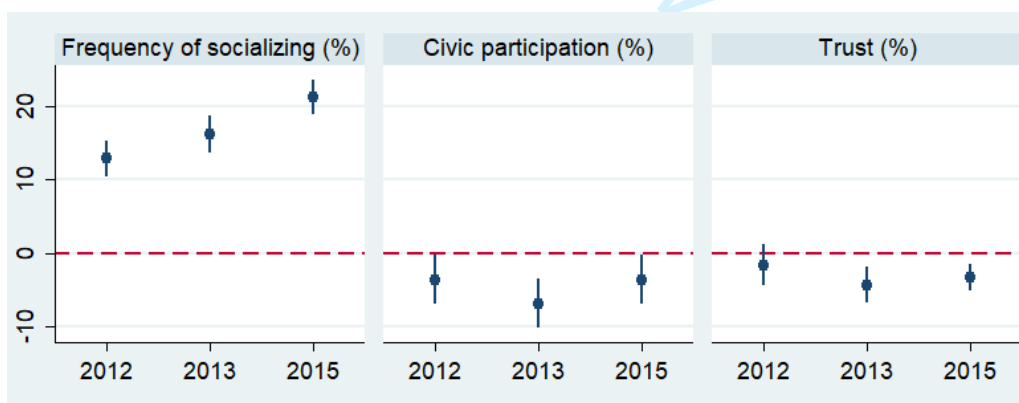
ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; “poor” physical health and “poor” mental health were references of the dependent variables in each model

Figure 1a Trends of health outcomes, 2010-2015 ($N=42,829$)



ORs with 95% CI were reported with 2010 as the reference year based on binary logistic models; “low” frequency of socializing, “low” trust and “no” civic participation were references of the dependent variables in each model

Figure 1b Trends of individual-level social capital, 2010-2015 ($N=42,829$)



Coefficients (β) with 95% CI were reported with 2010 as the reference year based on linear regression models

Figure 1c Trends of county-level social capital, 2010-2015 ($N=520$)

Supplementary Materials and Data

Supplementary Material 1: Details of the questions for social capital indicators

Frequency of socializing We assessed respondents' frequency of socializing by the question "How often did you engage in social interactions in your spare time in the past year?" Responses were categorized into "low" (including "never", "seldom", and "sometimes") and "high" (including "often" and "very frequently") frequency.

Civic participation We assessed civic participation by the question "Did you vote in the latest neighborhood/village committee election?". According to related laws,^{1,2} neighborhood committees and village committees are the basic-level administrative units, and residents aged 18 or above in each neighborhood/village directly elect members to the two committees. Hence, voting in the election reflects people's willingness to participate in civic activities in a county. The voting rate in a county reflects the extent of a county's social cohesion, and this measurement has been used in several previous studies.³⁻⁶

Trust We measured respondents' trust of others based on the question "Generally speaking, do you agree that most people in the society are trustworthy?" Responses were categorized into "low" (including "strongly disagree", "disagree", and "neutral") and "high" (including "agree" and "strongly agree") trust.

Supplementary Material 2: Calculation of county-level social capital

We calculate county-level social capital by using two-level binary logistic regressions with individuals at Level 1 nested within counties at Level 2. Following a previous study,⁷ we estimated the variance component in each individual-level social capital variable that can be attributed to counties separately. This method was also used in several multilevel social capital studies.⁸⁻¹⁰ We adjusted for individual characteristics that can influence each individual-level social capital variable, including gender (male, female), age (years), ethnicity (*Han*, non-*Han*), marital status (married/cohabitation, never married/divorced/separated/widowed), education (primary school or below, junior secondary school, senior secondary school, and college or above), occupation, poverty, and places of residence (rural, urban).

Taking y_{ij} as a binary response on a social capital variable for respondent i in county j , the regression model was specified as follows:

$$\text{Log} \left(\frac{p_{ij}}{1 - p_{ij}} \right) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \dots + \beta_p x_{pij} + \mu_j$$

where $p_{ij} = Pr(y_{ij}=1)$, β_0 is the grand mean of the social capital variable, x_{pij} is the p th individual characteristics for respondent i in county j , and μ_j is the random effect at Level 2, i.e., the residuals at county level.

Based on the regression model above, the county-level social capital of county j was calculated by the sum of β_0 and μ_j . We transformed the coefficient to probability, i.e., $p_{ij} = \frac{e^{(\beta_0 + \mu_j)}}{1 + e^{(\beta_0 + \mu_j)}}$, which means the probability of $y_{ij}=1$ for county j in which respondent i lived after adjusting for individual characteristics. In other words, it is the probability of $y_{ij}=1$ that can be attributed to counties after adjusting for individual characteristics (i.e., compositional factors). Hence, it is the contextual construct of social capital at county level.⁷ We reported the probability as a percentage. Higher percentage indicated higher county-level social capital.

We performed the above regression model for each of the three social capital variables (i.e., frequency of socializing, civic participation, and trust) in each year. For example, if y_{ij} is a response on trust

(1=high trust, 0=low trust) for respondent i in county j in 2010, then p_{ij} is the probability of high trust in county j where respondent i lived in 2010 after adjusting for individual characteristics of respondent i . In other words, if respondent i lived in county j in 2010, then taking other individual characteristics into account, the probability of he/she having high trust was p_{ij} and this probability, p_{ij} , could be attributed to living in county j .

Supplementary Material 3: Details of occupation and poverty

We classified occupation according to the International Standard Classification of Occupations 2008 (ISCO-08) (i.e., Skill level 3 or 4: managers, professionals, and technicians and associate professionals; Skill 2: clerical support workers; services and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators, and assemblers; Skill 1: elementary occupations).¹¹ We further included students, the unemployed, and retired people as “non-employed.”

We assessed poverty by equalized household income, which was calculated by dividing household income by the squared root of the number of household members. We defined respondents as “poor” if their equalized household annual incomes were less than or equal to half of the median equalized household annual income in each survey year. We further included “do not know income” as a separate category.

Supplementary Material 4: The weighting method used for two-level regression models

Studies have indicated that it is required to use scaling weights instead of the “raw” weights in multilevel models.¹²⁻¹⁴ Following previous studies,^{12,15} we calculated scaled individual-level weights as below:

$$w_{ij}^* = w_{ij} \left(\frac{n_j}{\sum_i w_{ij}} \right)$$

where w_{ij}^* is the scaled weight for individual i in cluster j , w_{ij} is the unscaled weight for individual i in cluster j , and n_j is the sample size in cluster j . Each county represents one cluster in our study.

Supplementary Material 5: Supplementary Tables**Supplementary Table 1. Missing data**

	2010	2012	2013	2015
	Total = 11,783	Total = 11,765	Total = 11,438	Total = 10,968
Gender	0	0	0	0
Age	9	4	2	0
Ethnicity	22	9	12	20
Marital status	8	0	23	0
Education	15	4	6	29
Annual household income	758	548	614	348
Number of household member	0	0	0	0
Occupation	80	74	107	218
Frequency of socializing	76	8	4	6
Trust	21	6	14	41
Civic participation	28	11	15	102
Place of residence	0	0	0	0
Physical health	15	4	2	7
Mental health	51	17	21	26

Supplementary Table 2. Unweighted sample characteristics

	2010	2012	2013	2015
	Mean±SD/%	Mean±SD/%	Mean±SD/%	Mean±SD/%
Individual level	<i>N</i> = 10,827	<i>N</i> = 11,104	<i>N</i> = 10,663	<i>N</i> = 10,235
Physical Health				
Poor	41.71	44.09	35.81	40.12
Good	58.29	55.91	64.19	59.88
Mental Health				
Poor	34.24	34.77	28.79	32.34
Good	65.76	65.23	71.21	67.66
Sociodemographic factors				
Gender				
Female	51.79	48.83	49.85	53.10
Male	48.21	51.17	50.15	46.90
Age (years)	47.50±15.66	49.07±16.22	48.72±16.44	50.61±16.91
Ethnicity				
Non-Han	9.11	8.79	8.59	7.96
Han	90.89	91.21	91.41	92.04
Marital status				
Single/separated/divorced/widowed	19.44	19.92	21.00	21.71
Cohabit/married	80.56	80.08	79.00	78.29
Socioeconomic factors				
Education				
Primary school or below	36.92	37.23	36.18	38.21
Junior secondary school	29.52	28.31	29.04	28.52
Senior secondary school or equal	19.13	18.86	18.88	17.81
College or above	14.44	15.60	15.90	15.46
Occupation				
Skill 3 or 4	10.32	12.81	11.54	9.83
Skill 2	50.12	48.06	47.25	42.61
Skill 1	3.61	2.88	3.48	4.14
Non-employed	35.96	36.25	37.74	43.42
Poverty				
Poor	12.08	16.38	14.67	17.10
Non-poor	81.68	76.31	77.06	77.54
Do not know income	6.24	7.30	8.27	5.36
Place of residence				
Urban	59.64	59.68	59.98	57.82
Rural	40.36	40.32	40.02	42.18
Social capital				
Frequency of socializing				
Low	78.05	74.07	72.29	72.26
High	21.95	25.93	27.71	27.74
Civic participation				

No	53.59	50.93	56.13	52.87
Yes	46.41	49.07	43.87	47.13
Trust				
Low	33.92	35.27	43.62	35.89
High	66.08	64.73	56.38	64.11
County level	<i>N</i> = 133	<i>N</i> = 131	<i>N</i> = 126	<i>N</i> = 130
Social Capital				
Frequency of socializing (%)	19.57±6.38	31.43±8.58	34.66±11.25	38.95±9.61
Civic participation (%)	25.17±12.15	21.13±9.99	18.77±10.68	22.87±14.25
Trust (%)	46.87±7.29	45.80±9.25	42.23±10.31	43.92±6.36

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Supplementary Table 3. Associations of individual- and county-level social capital with physical health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” physical health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.50*** (1.30,1.74)	1.38*** (1.20,1.59)	1.19* (1.03,1.38)	1.37*** (1.19,1.57)	1.19** (1.06,1.33)	1.24*** (1.11,1.39)	1.20** (1.06,1.36)	1.24*** (1.10,1.41)
Age	0.96*** (0.95,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.97)	0.97*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)	0.96*** (0.96,0.96)	0.96*** (0.96,0.97)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	1.01 (0.74,1.37)	0.99 (0.75,1.30)	0.79 (0.59,1.06)	1.17 (0.88,1.56)	0.80 (0.61,1.05)	1.00 (0.77,1.30)	1.27 (0.95,1.69)	1.01 (0.76,1.34)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.02 (0.83,1.26)	0.98 (0.81,1.19)	0.96 (0.79,1.17)	1.00 (0.83,1.21)	1.03 (0.89,1.19)	0.87 (0.75,1.00)	1.04 (0.90,1.22)	0.89 (0.76,1.03)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.39*** (1.17,1.64)	1.49*** (1.27,1.74)	1.64*** (1.39,1.95)	1.24* (1.05,1.47)	0.97 (0.82,1.14)	0.92 (0.79,1.08)	0.94 (0.79,1.12)	1.02 (0.87,1.21)

5	Senior secondary school or equal	1.49**	1.53**	1.54**	2.08***	1.15	1.18	1.25*	1.21*
6		(1.14,1.96)	(1.18,1.99)	(1.17,2.03)	(1.57,2.75)	(0.97,1.36)	(0.99,1.40)	(1.04,1.52)	(1.00,1.45)
7	College or above	1.60	2.77***	3.18***	1.78*	1.26*	1.25*	1.28*	1.46***
8		(0.84,3.04)	(1.53,5.00)	(1.72,5.89)	(1.09,2.89)	(1.02,1.55)	(1.02,1.52)	(1.02,1.60)	(1.17,1.83)
10	Poverty								
11	Poor	1	1	1	1	1	1	1	1
12	Non-poor	1.70***	1.59***	1.56***	1.60**	1.25	1.73***	1.83***	1.54***
13		(1.42,2.03)	(1.36,1.87)	(1.31,1.85)	(1.37,1.88)	(0.98,1.60)	(1.39,2.15)	(1.46,2.30)	(1.24,1.91)
14	Do not know income	1.58**	1.54**	1.28	1.02	1.24	1.33	1.71***	1.53*
15		(1.13,2.19)	(1.17,2.03)	(0.98,1.69)	(0.74,1.41)	(0.89,1.73)	(0.98,1.79)	(1.26,2.32)	(1.10,2.14)
17	Occupation								
19	Skill level 3 or 4	1	1	1	1	1	1	1	1
20	Skill level 2	0.91	0.88	0.78	1.17	0.89	0.97	1.00	0.97
21		(0.56,1.48)	(0.58,1.36)	(0.48,1.26)	(0.73,1.86)	(0.73,1.09)	(0.82,1.16)	(0.82,1.23)	(0.78,1.22)
22	Skill level 1	1.53	1.24	1.03	1.29	1.04	0.89	0.93	0.73
23		(0.79,2.94)	(0.66,2.30)	(0.53,1.99)	(0.72,2.28)	(0.75,1.45)	(0.64,1.24)	(0.66,1.32)	(0.52,1.03)
24	Non-employed	0.64	0.74	0.49**	1.00	0.65***	0.74**	0.64***	0.70**
25		(0.39,1.06)	(0.48,1.15)	(0.30,0.80)	(0.62,1.60)	(0.53,0.80)	(0.61,0.88)	(0.52,0.80)	(0.56,0.87)
28	Individual-level social capital								
29	Frequency of socializing								
31	Low	1	1	1	1	1	1	1	1
32	High	1.45***	1.50***	1.28**	1.37***	1.51***	1.33***	1.27**	1.34***
33		(1.19,1.76)	(1.27,1.78)	(1.10,1.50)	(1.19,1.59)	(1.31,1.73)	(1.17,1.51)	(1.09,1.47)	(1.15,1.55)
34	Civic participation								
36	No	1	1	1	1	1	1	1	1
37	Yes	1.04	1.00	0.89	0.88	0.97	1.01	1.12	1.09

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	(0.88,1.21)	(0.86,1.16)	(0.77,1.04)	(0.76,1.02)	(0.85,1.10)	(0.90,1.14)	(0.98,1.29)	(0.95,1.25)
Trust								
Low	1	1	1	1	1	1	1	1
High	1.24**	1.26**	1.07	1.40**	1.39**	1.31**	1.35***	1.41***
	(1.06,1.45)	(1.09,1.46)	(0.92,1.24)	(1.21,1.62)	(1.23,1.56)	(1.17,1.47)	(1.20,1.54)	(1.24,1.59)
County-level social capital								
High frequency of socializing (%)	0.99	1.01	1.00	1.01*	0.99	1.00	1.00	1.01**
	(0.96,1.01)	(0.99,1.02)	(0.98,1.01)	(1.00,1.03)	(0.97,1.01)	(0.99,1.01)	(0.99,1.02)	(1.00,1.02)
Civic participation (%)	1.01	1.00	1.00	0.99	1.00	0.99*	0.98*	0.99**
	(0.99,1.02)	(0.99,1.02)	(0.99,1.02)	(0.98,1.01)	(0.99,1.00)	(0.98,1.00)	(0.97,1.00)	(0.98,1.00)
Trust (%)	1.00	1.01	1.01	1.01	1.00	1.01	1.00	1.01
	(0.97,1.02)	(0.99,1.02)	(0.99,1.03)	(0.99,1.03)	(0.99,1.02)	(1.00,1.02)	(0.99,1.01)	(0.99,1.03)
<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
<i>N of counties</i> [#]	89	87	86	87	129	125	121	124
<i>ICC</i>	0.122	0.059	0.092	0.058	0.069	0.046	0.116	0.049

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[#] One county (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of counties in our study is not equal to the sum of the number of counties in rural samples and the number of counties in urban samples.

Supplementary Table 4. Associations of individual-level and county-level social capital with mental health, 2010-2015, stratified by place of residence (Two-level binary logistic model, with “poor” mental health as the reference group)

	Rural				Urban			
	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)	2010 Adjusted OR (95% CI)	2012 Adjusted OR (95% CI)	2013 Adjusted OR (95% CI)	2015 Adjusted OR (95% CI)
Sociodemographic factors								
Gender								
Female	1	1	1	1	1	1	1	1
Male	1.41*** (1.22,1.61)	1.47*** (1.28,1.69)	1.11 (0.96,1.29)	1.41*** (1.23,1.63)	1.13* (1.01,1.27)	1.24*** (1.10,1.38)	1.13 (1.00,1.27)	1.16* (1.02,1.31)
Age	0.98*** (0.98,0.99)	0.98*** (0.98,0.99)	0.99*** (0.99,1.00)	0.99*** (0.98,0.99)	0.99** (0.99,1.00)	1.00 (0.99,1.00)	0.99*** (0.98,0.99)	1.00 (0.99,1.00)
Ethnicity								
Non-Han	1	1	1	1	1	1	1	1
Han	0.89 (0.67,1.20)	0.91 (0.69,1.20)	0.86 (0.64,1.16)	0.97 (0.72,1.30)	0.93 (0.71,1.21)	1.26 (0.98,1.63)	1.19 (0.90,1.58)	1.16 (0.88,1.54)
Marriage								
Single/separated/divorced/widowed	1	1	1	1	1	1	1	1
Cohabit/married	1.16 (0.96,1.40)	1.13 (0.94,1.35)	1.46*** (1.21,1.75)	1.19* (1.00,1.43)	1.27*** (1.11,1.46)	1.21** (1.06,1.39)	1.20* (1.03,1.39)	1.19* (1.03,1.37)
Socioeconomic factors								
Education								
Primary school or below	1	1	1	1	1	1	1	1
Junior secondary school	1.33*** (1.13,1.57)	1.26** (1.07,1.48)	1.42*** (1.19,1.70)	1.09 (0.92,1.29)	1.30** (1.11,1.53)	1.18* (1.00,1.39)	1.05 (0.88,1.25)	1.43*** (1.21,1.69)

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Senior secondary school or equal	1.46**	1.39*	1.28	1.48**	1.44***	1.54***	1.31**	1.76***
	(1.12,1.90)	(1.06,1.82)	(0.97,1.69)	(1.12,1.94)	(1.21,1.71)	(1.30,1.84)	(1.08,1.59)	(1.46,2.12)
College or above	1.27	2.16**	3.48***	1.57	1.68***	1.51***	1.31*	1.94***
	(0.70,2.29)	(1.21,3.85)	(1.97,6.16)	(0.99,2.49)	(1.37,2.07)	(1.24,1.85)	(1.05,1.64)	(1.55,2.42)
Poverty								
Poor	1	1	1	1	1	1	1	1
Non-poor	1.69***	1.60***	1.78***	1.54***	1.77***	1.77***	1.77***	1.41**
	(1.43,2.01)	(1.37,1.87)	(1.50,2.11)	(1.31,1.80)	(1.40,2.22)	(1.43,2.18)	(1.42,2.22)	(1.14,1.74)
Do not know income	2.23***	1.49**	1.27	1.22	1.65**	1.61**	1.43*	1.45*
	(1.62,3.07)	(1.14,1.95)	(0.98,1.65)	(0.89,1.67)	(1.21,2.26)	(1.20,2.14)	(1.07,1.93)	(1.05,1.99)
Occupation								
Skill level 3 or 4	1	1	1	1	1	1	1	1
Skill level 2	0.73	0.91	1.00	1.28	1.04	0.98	0.96	1.14
	(0.45,1.18)	(0.59,1.43)	(0.62,1.61)	(0.81,2.01)	(0.86,1.26)	(0.82,1.17)	(0.79,1.17)	(0.92,1.42)
Skill level 1	0.66	0.61	0.95	1.22	1.34	1.16	1.04	1.03
	(0.35,1.21)	(0.32,1.13)	(0.49,1.82)	(0.69,2.14)	(0.96,1.87)	(0.83,1.62)	(0.74,1.47)	(0.73,1.44)
Non-employed	0.58*	0.85	0.70	1.05	1.00	1.01	0.99	1.00
	(0.36,0.95)	(0.54,1.34)	(0.43,1.15)	(0.66,1.65)	(0.82,1.22)	(0.85,1.22)	(0.80,1.22)	(0.81,1.24)
Individual-level social capital								
Frequency of socializing								
Low	1	1	1	1	1	1	1	1
High	1.11	1.25*	1.36***	1.54***	1.34***	1.18**	1.23**	1.17*
	(0.92,1.34)	(1.05,1.47)	(1.17,1.59)	(1.33,1.79)	(1.17,1.54)	(1.04,1.34)	(1.06,1.43)	(1.01,1.35)
Civic participation								
No	1	1	1	1	1	1	1	1
Yes	0.89	1.00	1.03	0.89	1.02	1.04	1.29***	1.13

	(0.77,1.04)	(0.86,1.15)	(0.89,1.21)	(0.76,1.03)	(0.90,1.16)	(0.92,1.18)	(1.12,1.48)	(0.99,1.30)
Trust								
Low	1	1	1	1	1	1	1	1
High	1.43***	1.36***	1.21**	1.58***	1.47***	1.48***	1.48***	1.33***
	(1.23,1.66)	(1.18,1.57)	(1.05,1.41)	(1.37,1.83)	(1.31,1.65)	(1.32,1.65)	(1.31,1.67)	(1.17,1.50)
County-level social capital								
Frequency of socializing (%)	0.99	1.00	1.00	1.02**	0.99	1.00	1.00	1.00
	(0.97,1.01)	(0.99,1.02)	(0.98,1.01)	(1.01,1.03)	(0.98,1.01)	(0.99,1.01)	(0.99,1.01)	(0.99,1.02)
Civic participation (%)	1.01	1.01	1.00	1.00	1.01	1.01	1.00	1.00
	(1.00,1.02)	(1.00,1.02)	(0.99,1.02)	(0.99,1.01)	(1.00,1.02)	(1.00,1.02)	(0.99,1.02)	(0.99,1.01)
Trust (%)	0.99	1.01	1.00	1.00	0.99	1.01*	0.99	1.00
	(0.97,1.01)	(0.99,1.02)	(0.98,1.02)	(0.98,1.03)	(0.98,1.00)	(1.00,1.02)	(0.98,1.01)	(0.99,1.02)
<i>N of individuals</i>	4,370	4,477	4,267	4,317	6,457	6,627	6,396	5,918
<i>N of counties</i> #	89	87	86	87	129	125	121	124
<i>ICC</i>	0.084	0.077	0.106	0.072	0.054	0.060	0.130	0.053

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

One county (i.e., county-level administrative unit) could include both rural and urban samples. Hence, the total number of counties in our study is not equal to the sum of the number of counties in rural samples and the number of counties in urban samples.

Supplementary Table 5. Associations of individual- and county-level social capital, national GDP, and annually national GDP growth with physical health and mental health, pooled data from 2010-2015 (Multi-level binary logistic model, with “poor” physical health and “poor” mental health as references)

	Two-level models without GDP		Three-level models with GDP and GDP growth		Two-level models with GDP and GDP Growth at Level-1 [#]	
	Physical health	Mental health	Physical health	Mental health	Physical health	Mental health
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors						
Gender						
Female	1	1	1	1	1	1
Male	1.28*** (1.23,1.34)	1.23*** (1.18,1.28)	1.28*** (1.23,1.34)	1.23*** (1.18,1.29)	1.28*** (1.24,1.33)	1.23*** (1.15,1.32)
Age	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)	0.96*** (0.96,0.96)	0.99*** (0.99,0.99)
Ethnicity						
Non-Han	1	1	1	1	1	1
Han	0.98 (0.89,1.09)	0.95 (0.86,1.05)	0.98 (0.89,1.09)	0.96 (0.87,1.07)	0.98 (0.90,1.07)	0.96 (0.88,1.05)
Marriage						
Single/separated/divorced/widowed	1	1	1	1	1	1
Cohabit/married	0.95 (0.90,1.01)	1.23*** (1.17,1.30)	0.96 (0.91,1.02)	1.24*** (1.17,1.31)	0.96 (0.91,1.02)	1.24*** (1.20,1.28)
Socioeconomic factors						
Education						
Primary school or below	1	1	1	1	1	1
Junior secondary school	1.18***	1.27***	1.19***	1.27***	1.19***	1.27***

	(1.11,1.25)	(1.19,1.34)	(1.13,1.26)	(1.20,1.35)	(1.13,1.25)	(1.22,1.33)
Senior secondary school or equal	1.38***	1.47***	1.40***	1.48***	1.40***	1.48***
	(1.29,1.48)	(1.37,1.58)	(1.30,1.50)	(1.38,1.59)	(1.32,1.47)	(1.38,1.59)
College or above	1.48***	1.53***	1.53***	1.56***	1.53***	1.56***
	(1.35,1.62)	(1.40,1.67)	(1.40,1.68)	(1.43,1.71)	(1.45,1.62)	(1.48,1.64)
Poverty						
Poor	1	1	1	1	1	1
Non-poor	1.62***	1.68***	1.62***	1.71***	1.62***	1.71***
	(1.52,1.73)	(1.58,1.79)	(1.52,1.73)	(1.61,1.82)	(1.56,1.68)	(1.60,1.83)
Do not know income	1.43***	1.52***	1.44***	1.51***	1.45***	1.51***
	(1.29,1.58)	(1.38,1.67)	(1.30,1.60)	(1.36,1.66)	(1.36,1.55)	(1.30,1.75)
Occupation						
Skill level 3 or 4	1	1	1	1	1	1
Skill level 2	0.94	1.08	0.94	1.06	0.94***	1.06
	(0.87,1.03)	(0.99,1.17)	(0.86,1.02)	(0.97,1.16)	(0.90,0.97)	(0.98,1.15)
Skill level 1	1.02	1.07	1.01	1.08	1.01	1.08*
	(0.88,1.17)	(0.93,1.23)	(0.87,1.16)	(0.94,1.24)	(0.87,1.16)	(1.01,1.15)
Non-employed	0.72***	0.99	0.71***	0.99	0.71***	0.99
	(0.65,0.78)	(0.91,1.08)	(0.64,0.77)	(0.90,1.08)	(0.64,0.78)	(0.92,1.05)
Place of residence						
Rural	1	1	1	1	1	1
Urban	1.20***	1.06*	1.20***	1.07*	1.20***	1.07*
	(1.13,1.27)	(1.00,1.12)	(1.13,1.27)	(1.01,1.13)	(1.09,1.31)	(1.00,1.15)
Individual-level social capital						
Frequency of socializing						
Low	1	1	1	1	1	1

High	1.34*** (1.27,1.41)	1.27*** (1.21,1.33)	1.37*** (1.30,1.44)	1.28*** (1.22,1.35)	1.37*** (1.29,1.44)	1.28*** (1.22,1.35)
Civic participation						
No	1 (0.95,1.05)	1 (0.99,1.09)	1 (0.96,1.06)	1 (1.00,1.10)	1 (1.00,1.02)	1 (0.98,1.12)
Yes	1.00 (0.95,1.05)	1.04 (0.99,1.09)	1.01 (0.96,1.06)	1.05 (1.00,1.10)	1.01 (1.00,1.02)	1.05 (0.98,1.12)
Trust						
Low	1 (1.23,1.35)	1 (1.33,1.46)	1 (1.25,1.37)	1 (1.36,1.49)	1 (1.23,1.39)	1 (1.37,1.46)
High	1.29*** (1.23,1.35)	1.39*** (1.33,1.46)	1.31*** (1.25,1.37)	1.42*** (1.36,1.49)	1.31*** (1.23,1.39)	1.42*** (1.37,1.46)
County-level social capital						
Frequency of socializing (%)	1.01*** (1.00,1.01)	1.01*** (1.00,1.01)	1.00 (1.00,1.01)	1.00 (0.99,1.01)	1.00 (1.00,1.01)	1.00 (1.00,1.00)
Civic participation (%)	0.99*** (0.99,1.00)	1.00 (1.00,1.00)	0.99** (0.99,1.00)	1.00 (1.00,1.01)	0.99*** (0.99,1.00)	1.00 (1.00,1.01)
Trust (%)	1.00 (1.00,1.01)	1.00 (1.00,1.01)	1.01* (1.00,1.01)	1.00 (0.99,1.01)	1.01** (1.00,1.01)	1.00 (0.99,1.01)
Year						
National GDP (trillion yuan)	--	--	1.03 (0.99,1.06)	1.01 (0.98,1.04)	1.03 (1.00,1.06)	1.01 (0.98,1.04)
Annually National GDP Growth (%)	--	--	1.13 (0.87,1.46)	1.02 (0.81,1.30)	1.13 (0.94,1.36)	1.03 (0.87,1.22)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>N of counties</i>	520	520	520	520	520	520
<i>N of years</i>	--	--	4	4	--	--
<i>ICC (At year level)</i>	--	--	0.003	0.003	--	--

ICC (At county level)

0.041

0.040

0.079

0.080

0.078

0.080

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; 1 trillion *yuan* \approx 141 billion US\$

As ICCs at the year level were too small in the previous three-level models, we treat National GDP and Annually National GDP Growth as Level 1 factors. We calculated 95%CI based on the standard errors clustered on the year level given that observations within each year might not be independent with each other.

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Supplementary Table 6. Interaction effects between social capital indicators and survey year on physical health, pooled data from 2010-2015 (Two-level binary logistic model, with “poor” physical health as references)

	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Interaction term						
<i>Individual-level social capital</i>						
High frequency of socializing × 2010	1	--	--	--	--	--
High frequency of socializing × 2012	0.95 (0.82,1.10)	--	--	--	--	--
High frequency of socializing × 2013	0.88 (0.76,1.01)	--	--	--	--	--
High frequency of socializing × 2015	1.01 (0.87,1.16)	--	--	--	--	--
Civic participation (Yes) × 2010	--	1	--	--	--	--
Civic participation (Yes) × 2012	--	0.93 (0.83,1.05)	--	--	--	--
Civic participation (Yes) × 2013	--	0.91 (0.81,1.03)	--	--	--	--
Civic participation (Yes) × 2015	--	0.91 (0.81,1.03)	--	--	--	--
High trust × 2010	--	--	1	--	--	--
High trust × 2012	--	--	0.98 (0.87,1.11)	--	--	--
High trust × 2013	--	--	0.90 (0.79,1.02)	--	--	--
High trust × 2015	--	--	1.08	--	--	--

				(0.95,1.22)		
County-level social capital						
High frequency of socializing × 2010	--	--	--		--	--
High frequency of socializing × 2012	--	--	--	1.00 (0.99,1.00)	--	--
High frequency of socializing × 2013	--	--	--	1.00 (1.00,1.00)	--	--
High frequency of socializing × 2015	--	--	--	1.02 (1.01,1.00)	--	--
Civic participation (Yes) × 2010	--	--	--		1	--
Civic participation (Yes) × 2012	--	--	--		0.99* (0.99,1.00)	--
Civic participation (Yes) × 2013	--	--	--		1.00 (0.99,1.00)	--
Civic participation (Yes) × 2015	--	--	--		1.00 (0.99,1.00)	--
High trust × 2010	--	--	--		--	1
High trust × 2012	--	--	--		--	1.00 (0.99,1.01)
High trust × 2013	--	--	--		--	1.00 (0.99,1.01)
High trust × 2015	--	--	--		--	1.00 (0.99,1.01)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>ICC</i>	0.043	0.043	0.043	0.043	0.043	0.043

* p < 0.05, ** p < 0.01, *** p < 0.001; Year and all other variables in Table 2 and Table 3 are adjusted.

Supplementary Table 7. Interaction effects between social capital indicators and survey year on mental health, pooled data from 2010-2015 (Two-level binary logistic model, with “poor” mental health as references)

	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Interaction term						
<i>Individual-level social capital</i>						
High frequency of socializing × 2010	1	--	--	--	--	--
High frequency of socializing × 2012	0.93 (0.81,1.08)	--	--	--	--	--
High frequency of socializing × 2013	1.03 (0.89,1.19)	--	--	--	--	--
High frequency of socializing × 2015	1.10 (0.95,1.27)	--	--	--	--	--
Civic participation (Yes) × 2010	--	1	--	--	--	--
Civic participation (Yes) × 2012	--	1.09 (0.97,1.22)	--	--	--	--
Civic participation (Yes) × 2013	--	1.13 (1.00,1.27)	--	--	--	--
Civic participation (Yes) × 2015	--	1.02 (0.90,1.15)	--	--	--	--
High trust × 2010	--	--	1	--	--	--
High trust × 2012	--	--	1.04 (0.92,1.17)	--	--	--
High trust × 2013	--	--	0.96 (0.85,1.08)	--	--	--
High trust × 2015	--	--	1.02	--	--	--

				(0.90,1.16)		
County-level social capital						
High frequency of socializing × 2010	--	--	--		--	--
High frequency of socializing × 2012	--	--	--	(1.00,1.00)	--	--
High frequency of socializing × 2013	--	--	--	(1.00,1.00)	--	--
High frequency of socializing × 2015	--	--	--	1.02*	--	--
				(1.01,1.00)		
Civic participation (Yes) × 2010	--	--	--		1	--
Civic participation (Yes) × 2012	--	--	--		1.00	--
					(0.99,1.00)	
Civic participation (Yes) × 2013	--	--	--		0.99*	--
					(0.99,1.00)	
Civic participation (Yes) × 2015	--	--	--		1.00	--
					(0.99,1.00)	
High trust × 2010	--	--	--		--	1
High trust × 2012	--	--	--		--	1.01***
						(1.01,1.02)
High trust × 2013	--	--	--		--	1.01*
						(1.00,1.02)
High trust × 2015	--	--	--		--	1.01
						(1.00,1.02)
<i>N of individuals</i>	42,829	42,829	42,829	42,829	42,829	42,829
<i>ICC</i>	0.040	0.040	0.040	0.040	0.040	0.040

* p < 0.05, ** p < 0.01, *** p < 0.001; Year and all other variables in Table 2 and Table 3 are adjusted.

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Supplementary Table 8. Associations of individual- and county-level social capital with physical health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” physical health as the reference group)

	2010	2012	2013	2015
	Adjusted OR	Adjusted OR	Adjusted OR	Adjusted OR
	(95% CI)	(95% CI)	(95% CI)	(95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.24**	1.38***	1.14*	1.29***
	(1.08,1.43)	(1.23,1.55)	(1.02,1.28)	(1.14,1.46)
Age				
	0.96***	0.96***	0.96***	0.96***
	(0.95,0.96)	(0.95,0.96)	(0.96,0.97)	(0.96,0.96)
Ethnicity				
Non-Han	1	1	1	1
Han	0.86	0.92	0.91	0.97
	(0.73,1.01)	(0.73,1.15)	(0.65,1.26)	(0.76,1.25)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	0.92	0.95	1.10	0.92
	(0.80,1.04)	(0.78,1.15)	(0.92,1.32)	(0.80,1.07)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.33***	1.25**	1.48***	1.29**
	(1.15,1.53)	(1.09,1.43)	(1.22,1.79)	(1.09,1.53)
Senior secondary school or equal	1.40***	1.55***	1.74***	1.65***
	(1.18,1.67)	(1.30,1.83)	(1.42,2.13)	(1.37,1.98)
College or above	1.61***	1.63***	2.09***	1.92***
	(1.30,2.00)	(1.27,2.08)	(1.64,2.66)	(1.53,2.42)
Poverty				
Poor	1	1	1	1
Non-poor	1.66***	1.54***	1.57***	1.59***
	(1.39,1.97)	(1.31,1.81)	(1.33,1.87)	(1.34,1.88)
Do not know income	1.60***	1.55***	1.55***	1.24
	(1.24,2.07)	(1.23,1.95)	(1.22,1.96)	(0.91,1.68)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.87	0.83	0.81	1.03
	(0.70,1.07)	(0.64,1.07)	(0.64,1.02)	(0.81,1.30)
Skill level 1	1.37	0.79	0.99	1.03
	(0.94,1.99)	(0.54,1.17)	(0.74,1.33)	(0.73,1.47)
Non-employed	0.69**	0.74**	0.62***	0.89
	(0.55,0.87)	(0.59,0.93)	(0.50,0.77)	(0.70,1.13)

Place of residence				
Rural	1	1	1	1
Urban	1.01	1.10	1.15	1.18*
	(0.86,1.19)	(0.96,1.24)	(0.99,1.33)	(1.01,1.38)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.48***	1.40***	1.17*	1.26**
	(1.29,1.70)	(1.24,1.59)	(1.03,1.33)	(1.08,1.48)
Civic participation				
No	1	1	1	1
Yes	0.96	1.10	0.97	0.97
	(0.84,1.10)	(0.96,1.25)	(0.85,1.10)	(0.85,1.11)
Trust [#]				
Low	1	1	1	1
High	1.35***	1.32***	1.14	1.46***
	(1.21,1.52)	(1.17,1.48)	(0.99,1.30)	(1.28,1.67)
County-level social capital				
Frequency of socializing (%)	0.98*	1.01	1.00	1.02***
	(0.96,1.00)	(1.00,1.02)	(0.99,1.02)	(1.01,1.03)
Civic participation (%)	1.00	1.00	0.99	0.99
	(0.99,1.01)	(0.99,1.01)	(0.98,1.01)	(0.99,1.00)
Trust (%)	0.99	1.01	1.01	1.01
	(0.97,1.01)	(0.99,1.02)	(1.00,1.03)	(1.00,1.03)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130
<i>ICC</i>	0.096	0.059	0.093	0.043

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] p = 0.063 in 2013

Supplementary Table 9. Associations of individual- and county-level social capital with mental health, 2010-2015, based on weighted data (Two-level binary logistic model, with “poor” mental health as the reference group)

	2010		2012		2013		2015	
	Adjusted	OR	Adjusted	OR	Adjusted	OR	Adjusted	OR
	(95% CI)		(95% CI)		(95% CI)		(95% CI)	
Sociodemographic factors								
Gender								
Female		1		1		1		1
Male		1.22***		1.48***		1.04		1.30***
		(1.09,1.38)		(1.33,1.65)		(0.91,1.18)		(1.15,1.45)
Age								
		0.98***		0.98***		0.99***		0.99***
		(0.98,0.99)		(0.98,0.99)		(0.98,0.99)		(0.99,1.00)
Ethnicity								
Non-Han		1		1		1		1
Han		0.80*		0.98		0.93		0.93
		(0.66,0.98)		(0.79,1.21)		(0.68,1.28)		(0.74,1.15)
Marriage								
Single/separated/divorced/widowed		1		1		1		1
Cohabit/married		1.23**		1.16		1.47***		1.32***
		(1.06,1.43)		(0.99,1.35)		(1.24,1.73)		(1.12,1.55)
Socioeconomic factors								
Education								
Primary school or below		1		1		1		1
Junior secondary school		1.34***		1.23**		1.41***		1.31***
		(1.17,1.53)		(1.05,1.42)		(1.16,1.71)		(1.12,1.54)
Senior secondary school or equal		1.33**		1.62***		1.57**		1.65***
		(1.11,1.59)		(1.34,1.96)		(1.15,2.14)		(1.34,2.03)
College or above		1.43**		1.45***		2.02***		1.94***
		(1.12,1.81)		(1.17,1.80)		(1.47,2.77)		(1.51,2.48)
Poverty								
Poor		1		1		1		1
Non-poor		1.71***		1.58***		1.65***		1.55***
		(1.47,2.00)		(1.37,1.81)		(1.41,1.94)		(1.33,1.81)
Do not know income		1.92***		1.39**		1.34*		1.46*
		(1.48,2.50)		(1.10,1.77)		(1.07,1.67)		(1.09,1.95)
Occupation								
Skill level 3 or 4		1		1		1		1
Skill level 2		0.98		0.88		1.17		1.31*
		(0.78,1.24)		(0.70,1.10)		(0.87,1.56)		(1.01,1.69)
Skill level 1		0.94		0.65*		1.28		1.54
		(0.66,1.34)		(0.46,0.92)		(0.81,2.03)		(0.98,2.42)
Non-employed		0.94		0.95		1.10		1.20
		(0.75,1.18)		(0.76,1.20)		(0.80,1.50)		(0.92,1.55)

Place of residence				
Rural	1	1	1	1
Urban	1.04 (0.90,1.19)	0.92 (0.79,1.06)	0.97 (0.84,1.12)	1.06 (0.93,1.22)
Individual-level social capital				
Frequency of socializing [#]				
Low	1	1	1	1
High	1.19 (1.00,1.42)	1.14* (1.00,1.31)	1.29*** (1.14,1.46)	1.36*** (1.17,1.59)
Civic participation				
No	1	1	1	1
Yes	0.96 (0.85,1.08)	0.95 (0.84,1.07)	1.10 (0.95,1.27)	0.93 (0.81,1.08)
Trust				
Low	1	1	1	1
High	1.43*** (1.28,1.59)	1.40*** (1.24,1.57)	1.27*** (1.12,1.46)	1.34*** (1.20,1.49)
County-level social capital				
Frequency of socializing (%)	0.99 (0.97,1.01)	1.01* (1.00,1.02)	1.00 (0.99,1.01)	1.01* (1.00,1.03)
Civic participation (%)	1.01 (1.00,1.01)	1.01 (1.00,1.02)	1.00 (0.99,1.01)	1.00 (0.99,1.01)
Trust (%)	0.98* (0.97,1.00)	1.01* (1.00,1.02)	1.00 (0.98,1.02)	1.00 (0.99,1.02)
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130
<i>ICC</i>	0.064	0.055	0.100	0.053

* p < 0.05, ** p < 0.01, *** p < 0.001

[#] p = 0.053 in 2010

Supplementary Table 10. Sensitivity analysis on associations of individual- and county-level social capital with physical health, 2010-2015 (Two-level ordinal logistic model)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.31*** (1.22,1.41)	1.38*** (1.29,1.49)	1.25*** (1.16,1.34)	1.29*** (1.20,1.39)
Age				
	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)	0.96*** (0.96,0.96)
Ethnicity				
Non-Han	1	1	1	1
Han	0.89 (0.76,1.05)	1.01 (0.86,1.19)	0.94 (0.80,1.12)	1.08 (0.90,1.28)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.00 (0.91,1.10)	0.96 (0.88,1.05)	1.00 (0.91,1.10)	0.94 (0.86,1.03)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.31*** (1.19,1.45)	1.22*** (1.11,1.35)	1.29*** (1.17,1.43)	1.19*** (1.07,1.31)
Senior secondary school or equal	1.43*** (1.27,1.61)	1.39*** (1.23,1.56)	1.52*** (1.35,1.71)	1.44*** (1.27,1.62)
College or above	1.36*** (1.17,1.57)	1.44*** (1.25,1.66)	1.45*** (1.26,1.68)	1.43*** (1.23,1.66)
Poverty				
Poor	1	1	1	1
Non-poor	1.85*** (1.64,2.09)	1.70*** (1.53,1.90)	1.82*** (1.63,2.04)	1.66*** (1.49,1.85)
Do not know income	1.76*** (1.47,2.11)	1.54*** (1.30,1.81)	1.61*** (1.37,1.90)	1.36** (1.13,1.64)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	0.95 (0.83,1.08)	0.97 (0.85,1.10)	0.99 (0.87,1.12)	1.05 (0.91,1.22)
Skill level 1	1.11 (0.89,1.39)	1.06 (0.84,1.35)	1.08 (0.86,1.35)	0.99 (0.79,1.24)
Non-employed	0.70*** (0.61,0.81)	0.79*** (0.69,0.90)	0.76*** (0.66,0.87)	0.84* (0.73,0.98)
Place of residence				

Rural	1	1	1	1
Urban	1.14**	1.20***	1.22***	1.36***
	(1.03,1.26)	(1.09,1.32)	(1.11,1.34)	(1.23,1.50)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.40***	1.35***	1.29***	1.35***
	(1.28,1.53)	(1.25,1.47)	(1.18,1.40)	(1.24,1.46)
Civic participation				
No	1	1	1	1
Yes	0.96	1.05	1.03	1.04
	(0.89,1.04)	(0.97,1.13)	(0.95,1.11)	(0.96,1.13)
Trust				
Low	1	1	1	1
High	1.24***	1.23***	1.19***	1.28***
	(1.15,1.33)	(1.14,1.33)	(1.11,1.28)	(1.19,1.39)
County-level social capital				
Frequency of socializing (%)				
	0.99	1.00	1.01*	1.01*
	(0.98,1.01)	(0.99,1.01)	(1.00,1.02)	(1.00,1.02)
Civic participation (%)				
	1.00	1.00	0.99	1.00
	(0.99,1.01)	(0.99,1.00)	(0.98,1.00)	(0.99,1.00)
Trust (%)				
	1.00	1.01	1.00	1.01
	(0.99,1.01)	(1.00,1.02)	(0.99,1.01)	(1.00,1.02)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

Supplementary Table 11. Sensitivity analysis on associations of individual- and county-level social capital with mental health, 2010-2015 (Two-level ordinal logistic model)

	2010	2012	2013	2015
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Sociodemographic factors				
Gender				
Female	1	1	1	1
Male	1.23*** (1.14,1.32)	1.37*** (1.27,1.47)	1.17*** (1.09,1.26)	1.23*** (1.14,1.32)
Age	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)	0.99*** (0.99,0.99)
Ethnicity				
Non-Han	1	1	1	1
Han	0.81* (0.69,0.96)	0.90 (0.76,1.07)	0.94 (0.79,1.11)	0.95 (0.80,1.14)
Marriage				
Single/separated/divorced/widowed	1	1	1	1
Cohabit/married	1.23*** (1.12,1.35)	1.23*** (1.12,1.34)	1.21*** (1.10,1.33)	1.14** (1.04,1.25)
Socioeconomic factors				
Education				
Primary school or below	1	1	1	1
Junior secondary school	1.35*** (1.22,1.49)	1.23*** (1.11,1.35)	1.24*** (1.12,1.37)	1.31*** (1.19,1.45)
Senior secondary school or equal	1.42*** (1.27,1.60)	1.49*** (1.33,1.68)	1.38*** (1.22,1.56)	1.51*** (1.34,1.71)
College or above	1.42*** (1.22,1.64)	1.50*** (1.30,1.74)	1.47*** (1.26,1.70)	1.62*** (1.39,1.89)
Poverty				
Poor	1	1	1	1
Non-poor	1.79*** (1.60,2.01)	1.70*** (1.53,1.89)	1.65*** (1.47,1.84)	1.56*** (1.40,1.73)
Do not know income	1.94*** (1.62,2.31)	1.57*** (1.34,1.85)	1.38*** (1.17,1.63)	1.40*** (1.16,1.68)
Occupation				
Skill level 3 or 4	1	1	1	1
Skill level 2	1.06 (0.93,1.22)	1.05 (0.92,1.19)	1.06 (0.93,1.22)	1.11 (0.96,1.28)
Skill level 1	1.19 (0.95,1.49)	1.06 (0.84,1.34)	0.99 (0.79,1.24)	1.03 (0.82,1.29)
Non-employed	0.96 (0.83,1.11)	1.11 (0.98,1.27)	1.03 (0.89,1.18)	1.07 (0.92,1.24)
Place of residence				

Rural	1	1	1	1
Urban	1.11*	1.03	1.10	1.19***
	(1.01,1.22)	(0.93,1.13)	(0.99,1.21)	(1.08,1.31)
Individual-level social capital				
Frequency of socializing				
Low	1	1	1	1
High	1.21***	1.20***	1.22***	1.28***
	(1.11,1.32)	(1.11,1.30)	(1.12,1.33)	(1.18,1.40)
Civic participation				
No	1	1	1	1
Yes	0.97	1.04	1.12**	1.06
	(0.90,1.05)	(0.96,1.12)	(1.04,1.22)	(0.98,1.15)
Trust				
Low	1	1	1	1
High	1.36***	1.32***	1.35***	1.35***
	(1.26,1.47)	(1.22,1.42)	(1.25,1.45)	(1.25,1.46)
County-level social capital				
Frequency of socializing (%)				
	1.00	1.00	1.01	1.00
	(0.99,1.02)	(0.99,1.01)	(0.99,1.02)	(0.99,1.01)
Civic participation (%)				
	1.01	1.01*	1.00	1.01
	(1.00,1.01)	(1.00,1.02)	(0.99,1.01)	(1.00,1.01)
Trust (%)				
	0.99	1.00	0.99	1.00
	(0.98,1.00)	(1.00,1.01)	(0.98,1.00)	(0.99,1.01)
<hr/>				
<i>N of individuals</i>	10,827	11,104	10,663	10,235
<i>N of counties</i>	133	131	126	130

* p < 0.05, ** p < 0.01, *** p < 0.001

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For peer review only

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

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	5
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	not applicable
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	6
		(d) If applicable, describe analytical methods taking account of sampling strategy	not applicable
		(e) Describe any sensitivity analyses	
Results			
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	6
		(b) Give reasons for non-participation at each stage	not applicable
		(c) Consider use of a flow diagram	not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7

		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	7
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	not applicable
		(b) Report category boundaries when continuous variables were categorized	5-6
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
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	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-11
Other information			
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	11

*Give information separately for exposed and unexposed groups.

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.