

Supplementary materials

Title: Association of digital exclusion with the risk of depression and the mediating effect of social activity: a multinational prospective cohort study

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I. Method: brief summary of five aging surveys

i. The Health and Retirement Study (HRS) ¹

HRS is conducted by the Institute for Social Research at the University of Michigan with funding from the National Institute on Aging (grant number NIA U01AG009740) and the Social Security Administration. It is a nationally representative longitudinal aging survey of more than 37000 individuals over age 50 in 23000 households in the USA. The HRS was initiated in 1992 and was followed every 2 years since then. Since 2006, a self-administered questionnaire has been utilized to obtain information about participants' evaluations of their circumstances, subjective wellbeing, and lifestyle, including social activity and loneliness. this psychosocial and lifestyle questionnaire is obtained in each biennial wave from a rotating (random) 50% of the core panel participants who complete the enhanced face-to-face interview. Therefore, individual longitudinal data are available at each four-year interval. In our study, we combined the two rotating half participants (those were first interviewed for psychological information in 2008 and 2010, respectively) into a whole to develop further analysis. **The latest ethical approval for HRS was obtained from the University of Michigan Institutional Review Board (IRB Protocol: HUM0061128).**²

ii. The English Longitudinal Study of Ageing (ELSA) ³

ELSA is a large scale longitudinal panel study of people aged 50 and over and their partners, living in private households in England. The study initiated in 2002 and the participants has been followed up every 2 years. ELSA is a multidisciplinary survey for collecting economic, social, psychological, cognitive, health, biological and genetic data. The total sample of ELSA in wave 1 included 12099 participants consisted of 11391 core members, and 708 partners. Different waves of ELSA received ethical approvals from multiple committees. **Waves included in our study received ethical approvals from the Berkshire Research Ethics Committee (wave 5: 2010/2011), the NRES Committee South Central – Berkshire (wave 6: 2012/2013, wave 7: 2014/2015), the South Central – Berkshire Research Ethics Committee (wave8: 2016/2017, wave 9: 2018/2019).**⁴

iii. The Survey of Health, Ageing and Retirement in Europe (SHARE) ⁵

SHARE is a multinational longitudinal survey of people aged 50 years and over. In wave 1 (2004/2005), SHARE contained 12 countries (Austria, Belgium, Switzerland, Germany, Denmark, Spain, France, Greece, Italy, Netherlands, Sweden, and Israel), and in wave 8, it extended to 30 countries in Europe. Most countries managed to collect data every 2 years. Up to wave 7, the data available to the scientific community are currently based on more than 375000 interviews administered on about 140000 respondents who participated in the surveys. The information collected in SHARE includes physical and mental health, economy, social networks, social activity, and so on. **During wave 1 to 4, SHARE was reviewed and approved by the Ethics Committee of the University of Mannheim.** Wave 4 and the continuation of the project were reviewed and approved by the Ethics Council of the Max Planck

Society. In addition, the country implementations of SHARE were reviewed and approved by the respective ethics committees or institutional review boards whenever this was required.⁶

iv. The China Health and Retirement Longitudinal Study (CHARLS) ⁷

CHARLS is a nationally representative longitudinal survey of adults aged 45 years and older and their spouses in China mainland. Similar to other aging surveys, it assesses social, economic, and health circumstances of community-residents. CHARLS initiated between June 2011 and March 2012 and involved 17708 respondents from 150 counties within in 28 provinces at baseline. Data collection is conducted at every 2-year follow-up. **The CHARLS was approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-14010). All participants provided written informed content.**

v. The Mexican Health and Aging Study (MHAS) ⁸

MHAS is a nationally and urban-rural representative survey conducted to evaluate the impact of disease on the health, function and mortality of adults over the age of 50 in Mexico, with a wide socioeconomic perspective. The baseline survey was conducted in summer 2001 with a completed-interviews sample size of 15186 respondents. Later in 2012, the sample was refreshed by a new sample of 6259 individuals and 385 partners, and the data collection newly included information about psychosocial measures, and new biomarkers.

II. Measurement of key variables

Table S1: The measurement of digital exclusion across five aging surveys.

Survey	Questions
Digital exclusion	
HRS	Do you regularly use the Internet (or the World Wide Web) for sending and receiving e-mail or for any other purpose, such as making purchases, searching for information, or making travel reservations? [1=Yes; 5=No]
ELSA	On average, how often do you use the Internet or email? [1=Every day, or almost every day; 2=At least once a week (but not every day); 3=At least once a month (but not every week); 4=At least once every 3 months; 5=Less than every 3 months; 6=Never]
SHARE	Wave 4: Do you regularly use the World Wide Web, or the Internet, for sending and receiving e-mail or for any other purpose, such as making purchases, searching for information, or making travel reservations? [1=Yes; 5=No] Wave 5-8: During the past 7 days, have you used the Internet, for e-mailing, searching for information, making purchases, or for any other purpose at least once? [1=Yes; 5=No]
CHARLS	Have you used the internet in the last month? [1=Yes; 0=No]
MHAS	Did you talk on the phone with relatives or use the computer to send messages or use the Internet during the past year? [1=Yes; 2=No] & How often did you perform it? [1=Weekly; 2=Monthly]

HRS: the Health and Retirement Study; ELSA: the English Longitudinal Study of Ageing; SHARE: the Survey of Health, Ageing and Retirement in Europe; CHARLS: the China Health and Retirement Longitudinal Study; MHAS: the Mexican Health and Ageing Study.

Table S2: The measurement of social activity and loneliness across five aging surveys

Survey	Questions
Social activity	
HRS	How often do you do each activity (<i>Do volunteer work; Do charity work; Go to a sport, social, or other club; Attend non-religious organizations</i>)? [1=Daily; 2=Several times a week; 3=Once a week; 4=At least once a month; 5=Not in the last month]
ELSA	Are you a member of any of these organisations, clubs or societies (<i>Political party; Church or other religious groups; Charitable associations; Social clubs; Sports clubs, gyms, exercise classes; Any other organisations, clubs or societies; None</i>)? [the number of choices selected]
SHARE	Have you done in the past twelve months (<i>Done voluntary or charity work; Gone to a sport, social or other kind of club; Taken part in activities of a religious organization; Taken part in a political or community-related organization</i>)? [the number of choices selected]
CHARLS	Have you done any of these activities in the last month (<i>Interacted with friends; Played Ma-jong, played chess, played cards, or went to community club; Went to a sport, social, or other kind of club; Took part in a community-related organization; Done voluntary or charity work</i>)? [the number of choices selected]
MHAS	If you did some of these activities during the past year (<i>Work as a volunteer or help a non-profit organization without pay or compensation; Attend a sporting or social club</i>)? [the number of choices selected]
Loneliness	
HRS	How much of the time do you feel (<i>Lack companionship; Left out; Isolated from others</i>)? [1=Hardly ever; 2=Some of the time; 3=Often]
ELSA	How much of the time do you feel (<i>Lack companionship; Left out; Isolated from others</i>)? [1=Hardly ever or never; 2=Some of the time; 3=Often]
SHARE	How much of the time do you feel (<i>Lack companionship; Left out; Isolated from others</i>)? [1=Hardly ever or never; 2=Some of the time; 3=Often]
CHARLS	How you have felt lonely during the last week? [0=<1 day; 1=1-2 days; 2=3-4 days; 3=5-7 days]
MHAS	If the majority of the time you felt lonely? [0=No; 1=Yes]
HRS: the Health and Retirement Study; ELSA: the English Longitudinal Study of Ageing; SHARE: the Survey of Health, Ageing and Retirement in Europe; CHARLS: the China Health and Retirement Longitudinal Study; MHAS: the Mexican Health and Ageing Study.	

III. Measurements of depressive symptoms

Table S3: CESD-8 and CESD-10. ^{9,10}

	CESD-8	CESD-10
Items	Please tell me how often you have felt this way during the past week. 1. I felt depressed. 2. I felt that everything I did was an effort. 3. My sleep was restless. 4. I was happy. 5. I felt lonely. * 6. I enjoyed life. 7. I felt sad. 8. I could not get “going”.	Please tell me how often you have felt this way during the past week. 1. I was bothered by things that don’t usually bother me. 2. had trouble keeping my mind on what I was doing. 3. I felt depressed. 4. I felt everything I did was an effort. 5. I felt hopeful about the future. 6. I felt fearful. 7. My sleep was restless. 8. I was happy. 9. I felt lonely. * 10. I could not get “going”.
Response	0=No, 1=Yes	0 = rarely or none of the time (<1 day) 1 = some or a little of the time (1–2 days) 2 = occasionally or a moderate amount of time (3–4 days) 3 = most or all of the time (5–7 days).
Scores	Range from 0 to 7	Range from 0 to 27
Cutoff	a score of 3 or higher	a score of 9 or higher
Surveys	HRS, ELSA, MHAS	CHARLS

*Item was excluded due to the overlap between loneliness and depression.

Table S4: Items and response options in EUROD-12 applied in SHARE. ¹¹

Items	Response options
Q1. In the last month, have you been sad or depressed?	1. Yes; 5. No
Q2. What are your hopes for the future?	1. Any hopes mentioned; 2. No hopes mentioned
Q3. In the last month, have you felt that you would rather be dead?	1. Any mention of suicidal feelings or wishing to be dead 2. No such feelings
Q4-1. Do you tend to blame yourself or feel guilty about anything?	1. Obvious excessive guilt or self-blame 2. No such feelings 3. Mentions guilt or self-blame, but it is unclear if these constitute obvious or excessive guilt or self-blame
Q4-2. So, for what do you blame yourself? (if Q4-1 = 3)	1. Example(s) given constitute obvious excessive guilt or self-blame 2. Example(s) do not constitute obvious excessive guilt or self-blame, or it remains unclear if these constitute obvious or excessive guilt or self-blame
Q5. Have you had trouble sleeping recently?	1. Trouble with sleep or recent change in pattern 2. No trouble sleeping
Q6-1. In the last month, what is your interest in things?	1. Less interest than usual mentioned 2. No mention of loss of interest 3. Non-specific or uncodeable response
Q6-2. So, do you keep up your interests? (if Q6-1 = 3)	1. Yes; 5. No
Q7. Have you been irritable recently?	1. Yes; 5. No
Q8-1. What has your appetite been like?	1. Diminution in desire for food 2. No diminution in desire for food 3. Non-specific or uncodeable response
Q8-2. So, have you been eating more or less than usual? (if Q8-1 = 3)	1. Less; 2. More; 3. Neither more nor less
Q9. In the last month, have you had too little energy to do the things you wanted?	1. Yes; 5. No
Q10-1. How is your concentration? For example, can you concentrate on a television programme, film or radio programme?	1. Difficulty in concentrating on entertainment 2. No such difficulty mentioned
Q10-2. Can you concentrate on something you read?	1. Difficulty in concentrating on entertainment 2. No such difficulty mentioned
Q11. What have you enjoyed doing recently?	1. Fails to mention any enjoyable activity 2. Mentions ANY enjoyment from activity
Q12. In the last month, have you cried at all?	1. Yes; 5. No

A score of 4 or higher is categorized as “case of depression”.

IV. Definition of covariates

Table S5: Harmonized definitions for covariates in the study.

Variables	Values	Definition in five surveys				
		HRS	ELSA	SHARE	CHARLS	MHAS
Social activity	Active	Respondents participated at least one social group in last month or year.				
	Inactive	Respondents did not participate any social groups in last month or year.				
Loneliness	Not lonely	Total score of R-UCLA loneliness scale is equal to 3.		Participants felt lonely <1 day during the last week.	Participants did not feel lonely in the majority of the time.	
	Lonely	Total score of R-UCLA loneliness scale is 4 and above.		Participants felt lonely >=1 day during the last week.	Participants felt lonely in the majority of the time.	
Family income level	Q1	Less than the first quartile of family income in each survey.				
	Q2	Less than the second quartile and more than the first quartile of family income in each survey.				
	Q3	Less than the third quartile and more than the second quartile of family income in each survey.				
	Q4	More than the third quartile of family income in each survey.				
Education	Less than upper secondary	According to the 1997 International Standard Classification of Education (ISCED). ¹²				
	Upper secondary and vocational training					
	Tertiary					
Labor force status	Not labor force or unemployed	Never work, unemployed, or sick				
	Employed	Employed or self-employed or other work				
	Retired	Retired				
Marital status	Married or partnered	Married and living together with/ separated from spouse; Partnered.				
	Single	Never married; Divorced; Widowed.				
Body-mas s index	Underweight or normal weight	Less than 25.0 kg/m ²		Less than 24.0 kg/m ²	Less than 25.0 kg/m ²	
	Overweight	25.0-29.9 kg/m ²		24.0-27.9 kg/m ²	25.0-29.9 kg/m ²	
	Obesity	30.0 and above kg/m ²		28.0 and above kg/m ²	30.0 and above kg/m ²	
Smoke	Never smoke	Participants never smoked.				
	Smoked	Participants had ever smoked but stopped at present.				
	Smoking	Participants smoke at present.				
Alcohol consumpti on	No	Participants never drunk alcoholic beverage.				
	Yes	Participants drink alcoholic beverage at present or previously.				

(continued)

Variables	Values	Definition in five surveys				
		HRS	ELSA	SHARE	CHARLS	MHAS
Physical inactivity	No	Frequency of taking part in vigorous/moderate physical activity: 1. <i>More than once a week</i> ; 2. <i>Once a week</i> .			Participants do vigorous/moderate physical activity for 10+ minutes at least 1 day a week.	Participants do physical work three or more times per week in the last two year.
	Yes	Frequency of taking part in vigorous/moderate physical activity: 1. <i>One to three times a month</i> ; 2. <i>Hardly ever or never</i> .			Participants do vigorous/moderate physical activity for less than 10 minutes every week.	Participants do not do physical work three or more times per week in the last two year.
Noncommunicable diseases	None	Participants do not have any communicable diseases.				
	1 or more	Participants have at least one communicable disease: hypertension, heart problems, stroke, diabetes, lung diseases, cancer, arthritis.				

V. Flow charts

Figure S1: Flow chart of participants included in total five aging surveys.

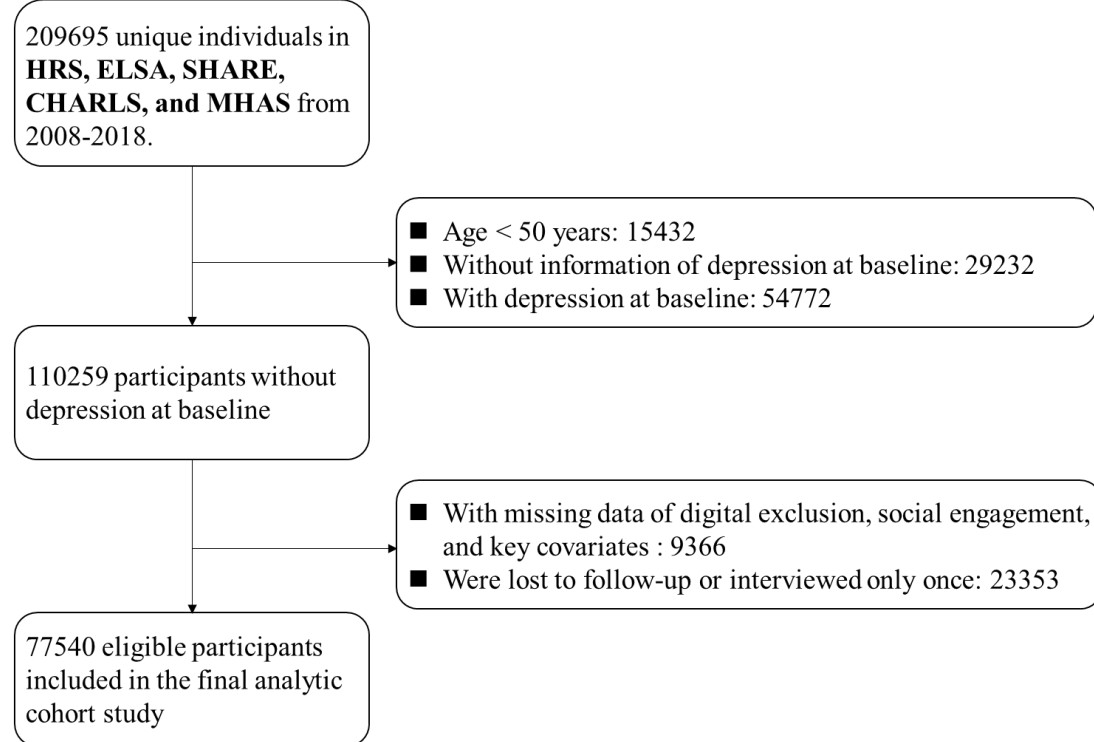


Figure S2: Flow chart of participants selected in the Health and Retirement Study (HRS).

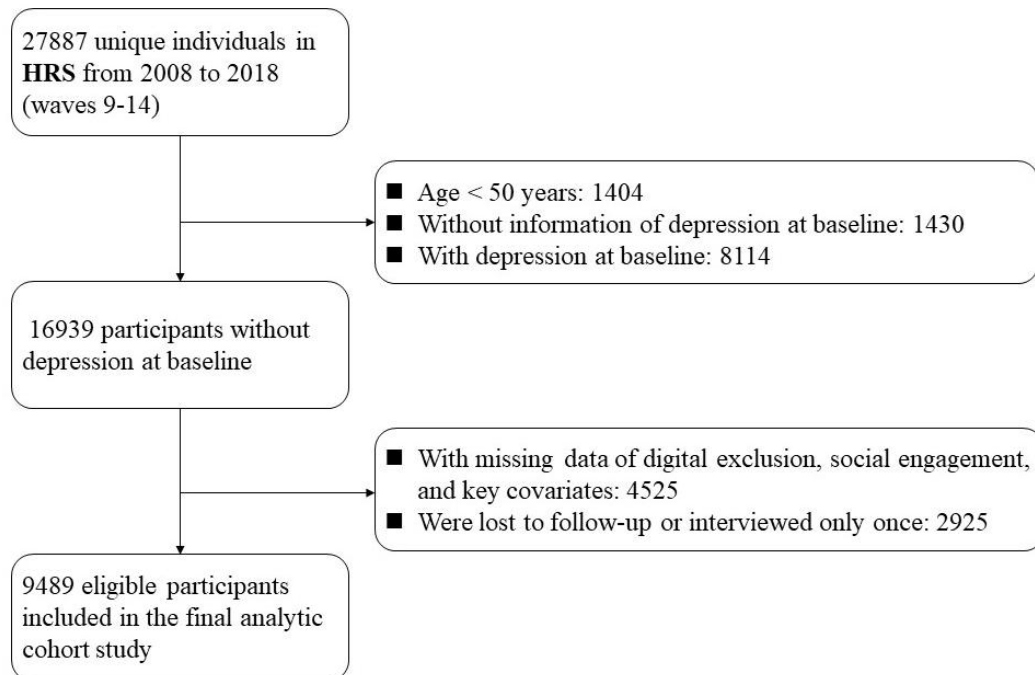


Figure S3: Flow chart of participants selected in the English Longitudinal Study of Ageing (ELSA).

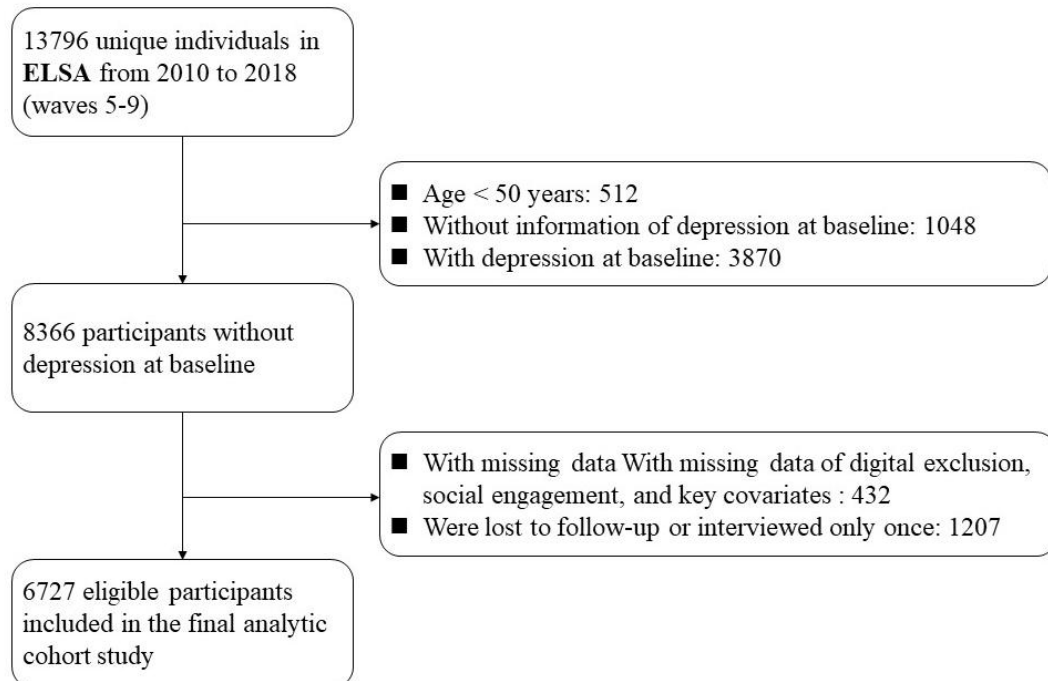


Figure S4: Flow chart of participants selected in the Survey of Health, Ageing and Retirement in Europe (SHARE).

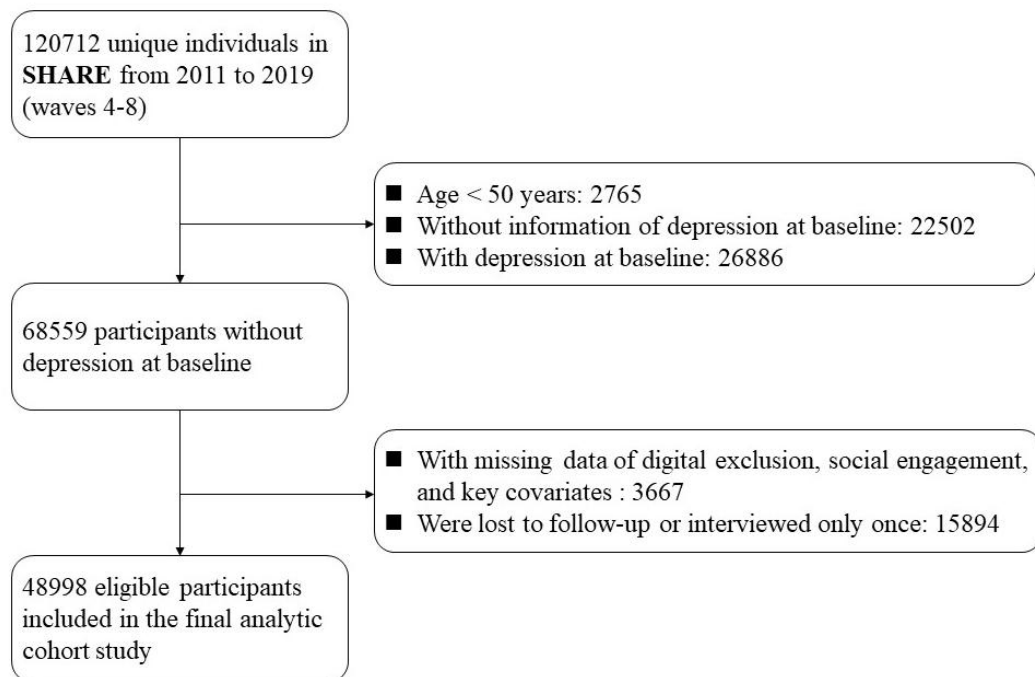


Figure S5: Flow chart of participants selected in the China Health and Retirement Longitudinal Study (CHARLS).

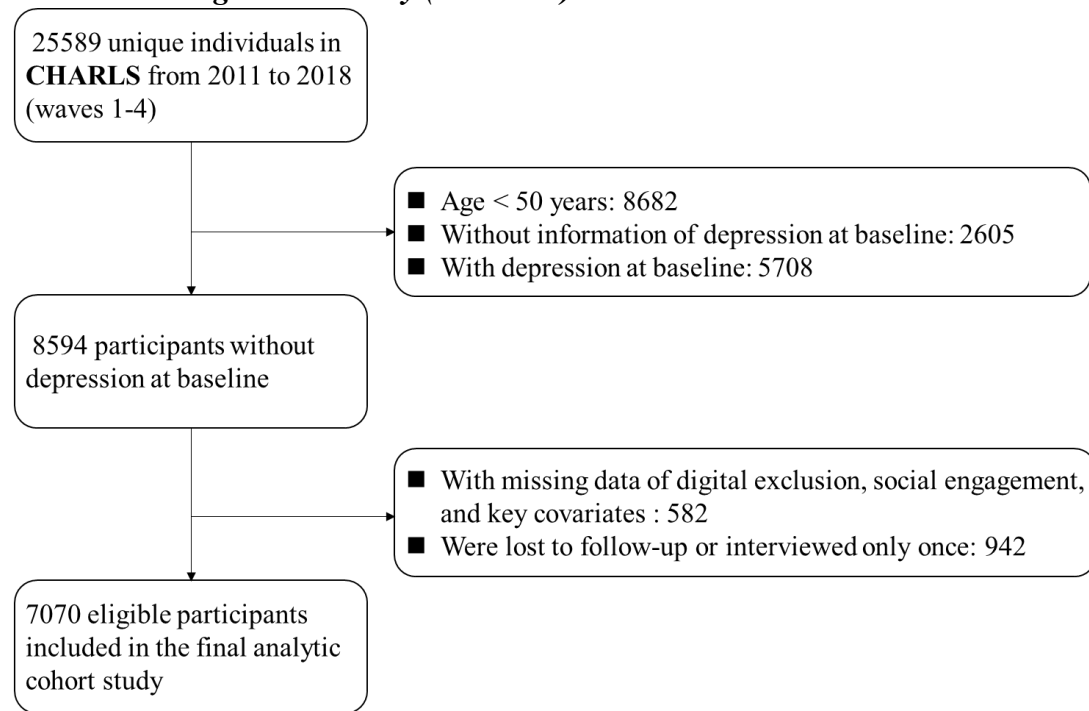
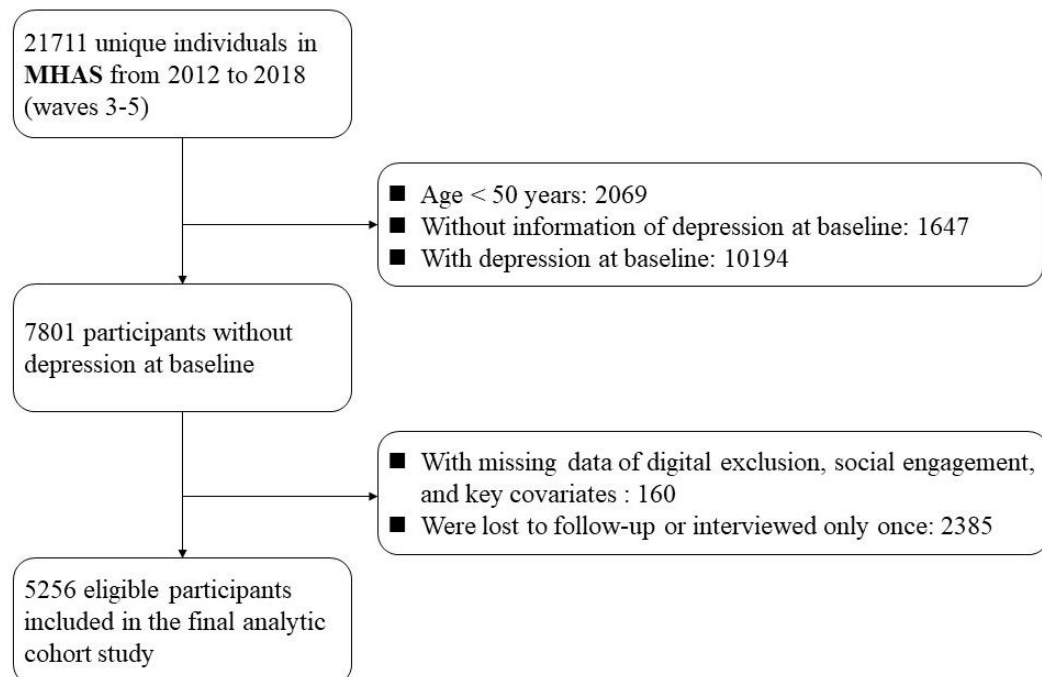
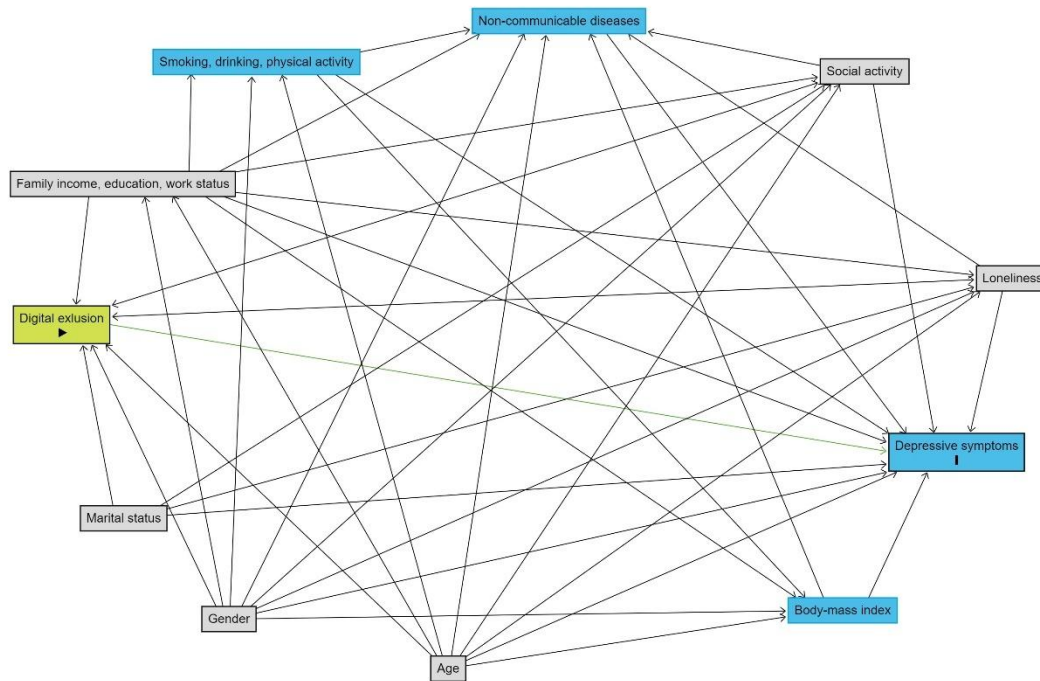


Figure S6: Flow chart of participants selected in the Mexican Health and Ageing Study (MHAS).



VI Directed Acyclic Graphs

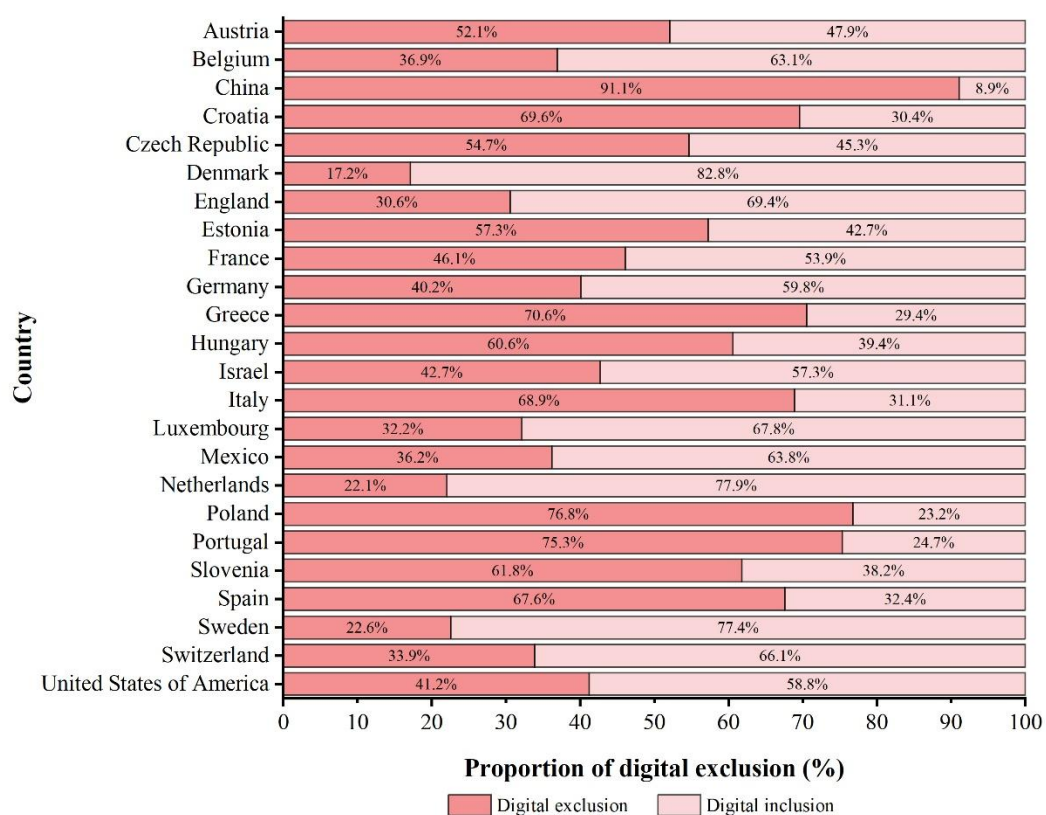
Figure S7: The casual directed acyclic graph of the association between digital exclusion and depression.



The grey rectangle represents the confounders. The minimal sufficient adjustment set includes gender, age, marital status, family income level, education, work status, social activity, and loneliness.

VII. Proportion of digital exclusion

Figure S8: Proportion of digital exclusion across 24 countries.



VIII. Baseline characteristics of participants

Table S6: Baseline characteristics of participants in HRS

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Total	5578 (58.8)	3911 (41.2)	9489 (100.0)		
Social activity				26.666	<0.001
Active	4464 (80.0)	2956 (75.6)	7420 (78.2)		
Inactive	1114 (20.0)	955 (24.4)	2069 (21.8)		
Loneliness				13.332	0.001
Not lonely	2888 (51.8)	1876 (48.0)	4764 (50.2)		
Lonely	2690 (48.2)	2035 (52.0)	4725 (49.8)		
Age (years)*				-31.995	<0.001
Median (Q1, Q3)	62 (56, 70)	70 (62, 77)	66 (58, 73)		
Gender				0.321	0.852
Male	2413 (43.3)	1669 (42.7)	4082 (43.0)		
Female	3165 (56.7)	2242 (57.3)	5407 (57.0)		
Marital status				198.584	<0.001
Single	1529 (27.4)	1613 (41.2)	3142 (33.1)		
Married or partnered	4049 (72.6)	2298 (58.8)	6347 (66.9)		
Education				1686.498	<0.001
Less than upper secondary	79 (1.4)	591 (15.1)	670 (7.1)		
Upper secondary	1577 (28.3)	2126 (54.4)	3703 (39.0)		
Tertiary	3922 (70.3)	1194 (30.5)	5116 (53.9)		
Family income				1641.391	<0.001
Q1 (lowest)	757 (13.6)	1614 (41.3)	2371 (25.0)		
Q2	1138 (20.4)	1226 (31.3)	2364 (24.9)		
Q3	1644 (29.5)	737 (18.8)	2381 (25.1)		
Q4 (highest)	2039 (36.6)	334 (8.5)	2373 (25.0)		
Work status				548.749	<0.001
Not working	416 (7.5)	397 (10.2)	813 (8.6)		
Working	2550 (45.7)	871 (22.3)	3421 (36.1)		
Retired	2612 (46.8)	2643 (67.6)	5255 (55.4)		
Body-mass index				6.552	0.162
Underweight or normal	1529 (27.4)	1128 (28.8)	2657 (28.0)		
Overweight	2238 (40.1)	1468 (37.5)	3706 (39.1)		
Obesity	1811 (32.5)	1315 (33.6)	3126 (32.9)		
Smoke				48.503	<0.001
Non-smoker	2613 (46.8)	1761 (45.0)	4374 (46.1)		
Past smoker	2438 (43.7)	1601 (40.9)	4039 (42.6)		
Current smoker	527 (9.4)	549 (14.0)	1076 (11.3)		
Drink				419.361	<0.001
No	1717 (30.8)	2020 (51.6)	3737 (39.4)		
Yes	3861 (69.2)	1891 (48.4)	5752 (60.6)		

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Physical inactivity				112.668	<0.001
No	4611 (82.7)	2880 (73.6)	7491 (78.9)		
Yes	967 (17.3)	1031 (26.4)	1998 (21.1)		
Noncommunicable diseases				145.413	<0.001
None	1366 (24.5)	562 (14.4)	1928 (20.3)		
1 or more	4212 (75.5)	3349 (85.6)	7561 (79.7)		

*Age was described by median, the first and the third quantile. †The differences of categorical variables were assessed by χ^2 tests, and the differences of continuous variables were compared by t tests.

Table S7: Baseline characteristics of participants in ELSA

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Total	4668 (69.4)	2059 (30.6)	6727 (100.0)		
Social activity				109.542	<0.001
Active	3378 (72.4)	1225 (59.5)	4603 (68.4)		
Inactive	1290 (27.6)	834 (40.5)	2124 (31.6)		
Loneliness				27.377	<0.001
Not lonely	2934 (62.9)	1155 (56.1)	4089 (60.8)		
Lonely	1734 (37.1)	904 (43.9)	2638 (39.2)		
Age (years)*				-36.529	<0.001
Median (Q1, Q3)	61 (56, 67)	71 (64, 77)	63 (57, 71)		
Gender				38.091	<0.001
Male	2360 (50.6)	873 (42.4)	3233 (48.1)		
Female	2308 (49.4)	1186 (57.6)	3494 (51.9)		
Marital status				246.915	<0.001
Single	821 (17.6)	722 (35.1)	1543 (22.9)		
Married or partnered	3847 (82.4)	1337 (64.9)	5184 (77.1)		
Education				581.17	<0.001
Less than upper secondary	159 (3.4)	339 (16.5)	498 (7.4)		
Upper secondary	3136 (67.2)	1524 (74.0)	4660 (69.3)		
Tertiary	1373 (29.4)	196 (9.5)	1569 (23.3)		
Family income				756.804	<0.001
Q1 (lowest)	819 (17.5)	863 (41.9)	1682 (25.0)		
Q2	990 (21.2)	625 (30.4)	1615 (24.0)		
Q3	1358 (29.1)	389 (18.9)	1747 (26.0)		
Q4 (highest)	1501 (32.2)	182 (8.8)	1683 (25.0)		
Work status				517.807	<0.001
Not working	99 (2.1)	70 (3.4)	169 (2.5)		
Working	2615 (56.0)	535 (26.0)	3150 (46.8)		
Retired	1954 (41.9)	1454 (70.6)	3408 (50.7)		
Body-mass index				169.846	<0.001
Underweight or normal	1418 (30.4)	650 (31.6)	2068 (30.7)		
Overweight	1644 (35.2)	850 (41.3)	2494 (37.1)		
Obesity	786 (16.8)	438 (21.3)	1224 (18.2)		
Unknown	820 (17.6)	121 (5.9)	941 (14.0)		
Smoke				37.616	<0.001
Non-smoker	1988 (42.6)	789 (38.3)	2777 (41.3)		
Past smoker	1942 (41.6)	819 (39.8)	2761 (41.0)		
Current smoker	525 (11.2)	325 (15.8)	850 (12.6)		
Unknown	213 (4.6)	126 (6.1)	339 (5.0)		
Drink				189.19	<0.001
No	277 (5.9)	339 (16.5)	616 (9.2)		
Yes	4391 (94.1)	1720 (83.5)	6111 (90.8)		

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Physical inactivity				227.005	<0.001
No	4184 (89.6)	1555 (75.5)	5739 (85.3)		
Yes	484 (10.4)	504 (24.5)	988 (14.7)		
Noncommunicable diseases				174.84	<0.001
None	2195 (47.0)	613 (29.8)	2808 (41.7)		
1 or more	2473 (53.0)	1446 (70.2)	3919 (58.3)		

*Age was described by median, the first and the third quantile. †The differences of categorical variables were assessed by χ^2 tests, and the differences of continuous variables were compared by t tests.

Table S8: Baseline characteristics of participants in SHARE

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Total	25481 (52.0)	23517 (48.0)	48998 (100.0)		
Social activity				2999.856	<0.001
Active	14802 (58.1)	7854 (33.4)	22656 (46.2)		
Inactive	10679 (41.9)	15663 (66.6)	26342 (53.8)		
Loneliness				393.099	<0.001
Not lonely	18554 (72.8)	15171 (64.5)	33725 (68.8)		
Lonely	6927 (27.2)	8346 (35.5)	15273 (31.2)		
Age (years)*				-88.974	<0.001
Median (Q1, Q3)	61 (56, 67)	69 (62, 76)	63 (57, 71)		
Gender				181.501	<0.001
Male	13131 (51.5)	10687 (45.4)	23818 (48.6)		
Female	12350 (48.5)	12830 (54.6)	25180 (51.4)		
Marital status				320.178	<0.001
Single	5277 (20.7)	6496 (27.6)	11773 (24.0)		
Married or partnered	20204 (79.3)	17021 (72.4)	37225 (76.0)		
Education				6089.656	<0.001
Less than upper secondary	4825 (18.9)	13141 (55.9)	17966 (36.7)		
Upper secondary	10874 (42.7)	8155 (34.7)	19029 (38.8)		
Tertiary	9782 (38.4)	2221 (9.4)	12003 (24.5)		
Family income				7360.923	<0.001
Q1 (lowest)	3998 (15.7)	9325 (39.7)	13323 (27.2)		
Q2	4978 (19.5)	7455 (31.7)	12433 (25.4)		
Q3	7493 (29.4)	4477 (19.0)	11970 (24.4)		
Q4 (highest)	9012 (35.4)	2260 (9.6)	11272 (23.0)		
Work status				5946.383	<0.001
Not working	2329 (9.1)	4089 (17.4)	6418 (13.1)		
Working	12443 (48.8)	3791 (16.1)	16234 (33.1)		
Retired	10709 (42.0)	15637 (66.5)	26346 (53.8)		
Body-mass index				351.505	<0.001
Underweight or normal	10314 (40.5)	7844 (33.4)	18158 (37.1)		
Overweight	10729 (42.1)	10319 (43.9)	21048 (43.0)		
Obesity	4438 (17.4)	5354 (22.8)	9792 (20.0)		
Smoke				248.727	<0.001
Non-smoker	9604 (37.7)	10350 (44.0)	19954 (40.7)		
Past smoker	11088 (43.5)	8750 (37.2)	19838 (40.5)		
Current smoker	4520 (17.7)	3890 (16.5)	8410 (17.2)		
Unknown	269 (1.1)	527 (2.2)	796 (1.6)		
Drink				2555.738	<0.001
No	4747 (18.6)	9236 (39.3)	13983 (28.5)		
Yes	20734 (81.4)	14281 (60.7)	35015 (71.5)		

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Physical inactivity				857.471	<0.001
No	24652 (96.7)	21233 (90.3)	45885 (93.6)		
Yes	829 (3.3)	2284 (9.7)	3113 (6.4)		
Noncommunicable diseases				1209.996	<0.001
None	13265 (52.1)	8566 (36.4)	21831 (44.6)		
1 or more	12216 (47.9)	14951 (63.6)	27167 (55.4)		

*Age was described by median, the first and the third quantile. †The differences of categorical variables were assessed by χ^2 tests, and the differences of continuous variables were compared by t tests.

Table S9: Baseline characteristics of participants in CHARLS

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Total	630 (8.9)	6440 (91.1)	7070 (100.0)		
Social activity				259.412	<0.001
Active	417 (66.2)	2176 (33.8)	2593 (36.7)		
Inactive	213 (33.8)	4264 (66.2)	4477 (63.3)		
Loneliness				12.872	0.002
Not lonely	569 (90.3)	5477 (85.0)	6046 (85.5)		
Lonely	61 (9.7)	963 (15.0)	1024 (14.5)		
Age (years)*				15.805	<0.001
Median (Q1, Q3)	56 (52, 60)	60 (55, 66)	59 (55, 66)		
Gender				11.014	0.004
Male	394 (62.5)	3585 (55.7)	3979 (56.3)		
Female	236 (37.5)	2855 (44.3)	3091 (43.7)		
Marital status				21.682	<0.001
Single	32 (5.1)	711 (11.0)	743 (10.5)		
Married or partnered	598 (94.9)	5729 (89.0)	6327 (89.5)		
Education				738.835	<0.001
Less than upper secondary	307 (48.7)	5697 (88.5)	6004 (84.9)		
Upper secondary	250 (39.7)	639 (9.9)	889 (12.6)		
Tertiary	73 (11.6)	104 (1.6)	177 (2.5)		
Family income				361.862	<0.001
Q1 (lowest)	48 (7.6)	1715 (26.6)	1763 (24.9)		
Q2	45 (7.1)	1427 (22.2)	1472 (20.8)		
Q3	204 (32.4)	1862 (28.9)	2066 (29.2)		
Q4 (highest)	333 (52.9)	1436 (22.3)	1769 (25.0)		
Work status				13.414	0.009
Not working	8 (1.3)	142 (2.2)	150 (2.1)		
Working	360 (57.1)	4065 (63.1)	4425 (62.6)		
Retired	262 (41.6)	2233 (34.7)	2495 (35.3)		
Body-mass index				65.878	<0.001
Underweight or normal	260 (41.3)	3573 (55.5)	3833 (54.2)		
Overweight	237 (37.6)	1888 (29.3)	2125 (30.1)		
Obesity	77 (12.2)	721 (11.2)	798 (11.3)		
Unknown	56 (8.9)	258 (4.0)	314 (4.4)		
Smoke				0.877	0.928
Non-smoker	350 (55.6)	3602 (55.9)	3952 (55.9)		
Past smoker	71 (11.3)	651 (10.1)	722 (10.2)		
Current smoker	209 (33.2)	2187 (34.0)	2396 (33.9)		
Drink				24.760	<0.001
No	337 (53.5)	4092 (63.5)	4429 (62.6)		
Yes	293 (46.5)	2348 (36.5)	2641 (37.4)		

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Physical inactivity				17.030	0.002
No	398 (63.2)	3715 (57.7)	4113 (58.2)		
Yes	219 (34.8)	2366 (36.7)	2585 (36.6)		
Unknown	13 (2.1)	359 (5.6)	372 (5.3)		
Noncommunicable diseases				31.585	<0.001
None	271 (43.0)	2709 (42.1)	2980 (42.2)		
1 or more	292 (46.3)	3385 (52.6)	3677 (52.0)		
Unknown	67 (10.6)	346 (5.4)	413 (5.8)		

*Age was described by median, the first and the third quantile. †The differences of categorical variables were assessed by χ^2 tests, and the differences of continuous variables were compared by t tests.

Table S10: Baseline characteristics of participants in MHAS

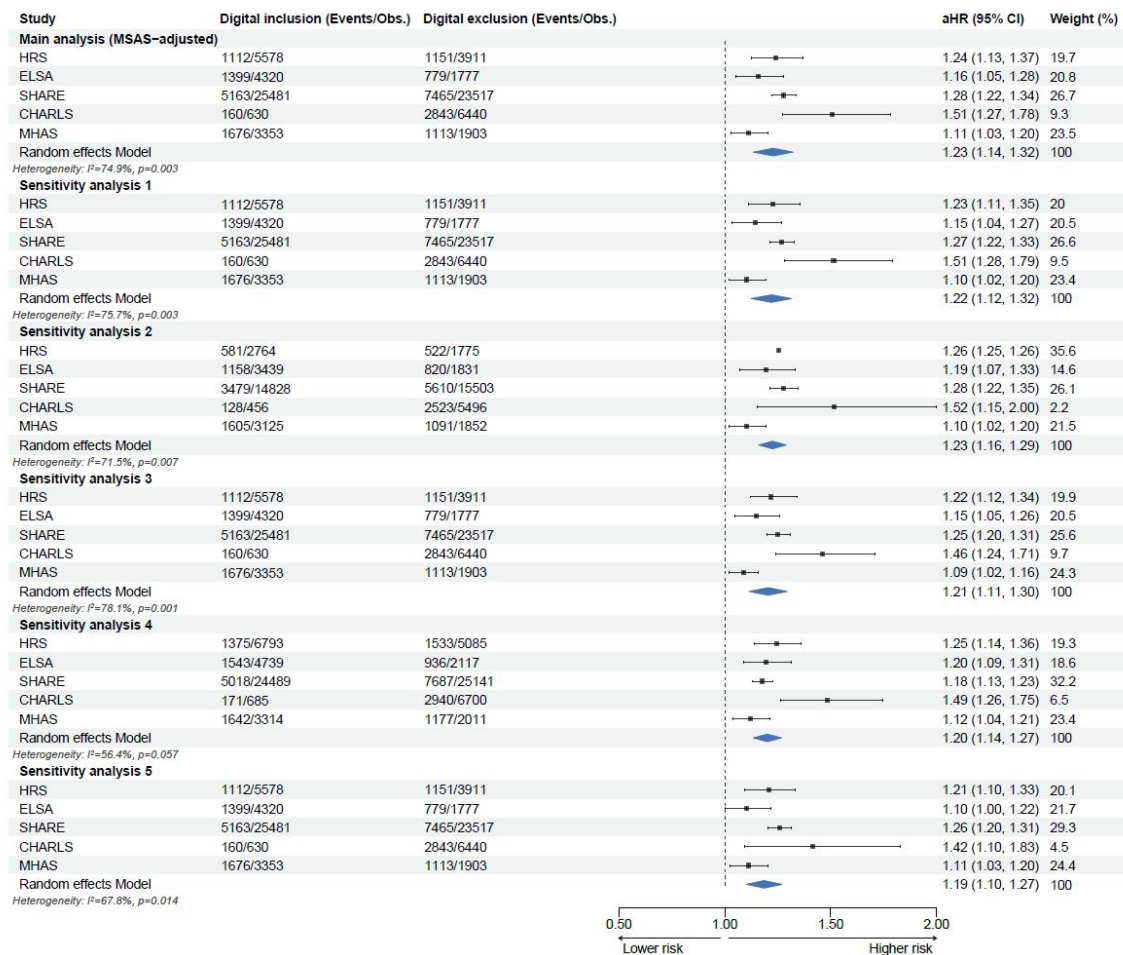
	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Total	3353 (63.8)	1903 (36.2)	5256 (100.0)		
Social activity				54.006	<0.001
Active	1740 (51.9)	787 (41.4)	2527 (48.1)		
Inactive	1613 (48.1)	1116 (58.6)	2729 (51.9)		
Loneliness				9.247	0.010
Not lonely	3135 (93.5)	1736 (91.2)	4871 (92.7)		
Lonely	218 (6.5)	167 (8.8)	385 (7.3)		
Age (years)*				-5.6898	<0.001
Median (Q1, Q3)	62 (56, 68)	64 (57, 70)	63 (57, 69)		
Gender				33.704	<0.001
Male	1629 (48.6)	1083 (56.9)	2712 (51.6)		
Female	1724 (51.4)	820 (43.1)	2544 (48.4)		
Marital status				0.867	0.648
Single	1035 (30.9)	611 (32.1)	1646 (31.3)		
Married or partnered	2318 (69.1)	1292 (67.9)	3610 (68.7)		
Education				241.036	<0.001
Less than upper secondary	2460 (73.4)	1736 (91.2)	4196 (79.8)		
Upper secondary	203 (6.1)	44 (2.3)	247 (4.7)		
Tertiary	690 (20.6)	123 (6.5)	813 (15.5)		
Family income				226.883	<0.001
Q1 (lowest)	734 (21.9)	577 (30.3)	1311 (24.9)		
Q2	662 (19.7)	581 (30.5)	1243 (23.6)		
Q3	898 (26.8)	458 (24.1)	1356 (25.8)		
Q4 (highest)	1059 (31.6)	287 (15.1)	1346 (25.6)		
Work status				46.674	<0.001
Not working	1220 (36.4)	847 (44.5)	2067 (39.3)		
Working	1532 (45.7)	823 (43.2)	2355 (44.8)		
Retired	601 (17.9)	233 (12.2)	834 (15.9)		
Body-mass index				93.703	<0.001
Underweight or normal	870 (25.9)	558 (29.3)	1428 (27.2)		
Overweight	1414 (42.2)	734 (38.6)	2148 (40.9)		
Obesity	890 (26.5)	387 (20.3)	1277 (24.3)		
Unknown	179 (5.3)	224 (11.8)	403 (7.7)		
Smoke				8.452	0.076
Non-smoker	1955 (58.3)	1171 (61.5)	3126 (59.5)		
Past smoker	965 (28.8)	477 (25.1)	1442 (27.4)		
Current smoker	433 (12.9)	255 (13.4)	688 (13.1)		
Drink				6.750	0.034
No	2341 (69.8)	1393 (73.2)	3734 (71.0)		
Yes	1012 (30.2)	510 (26.8)	1522 (29.0)		

	Digital inclusion (n, %)	Digital exclusion (n, %)	Overall (n, %)	Statistics†	p-value
Physical inactivity				1.677	0.432
No	1535 (45.8)	836 (43.9)	2371 (45.1)		
Yes	1818 (54.2)	1067 (56.1)	2885 (54.9)		
Noncommunicable diseases				8.550	0.073
None	1321 (39.4)	827 (43.5)	2148 (40.9)		
1 or more	2009 (59.9)	1066 (56.0)	3075 (58.5)		
Unknown	23 (0.7)	10 (0.5)	33 (0.6)		

*Age was described by median, the first and the third quantile. †The differences of categorical variables were assessed by χ^2 tests, and the differences of continuous variables were compared by t tests.

IX. Supplementary results for sensitivity analyses and subgroup analyses

Figure S9: Sensitivity analyses on the association of digital exclusion with the risk of depression



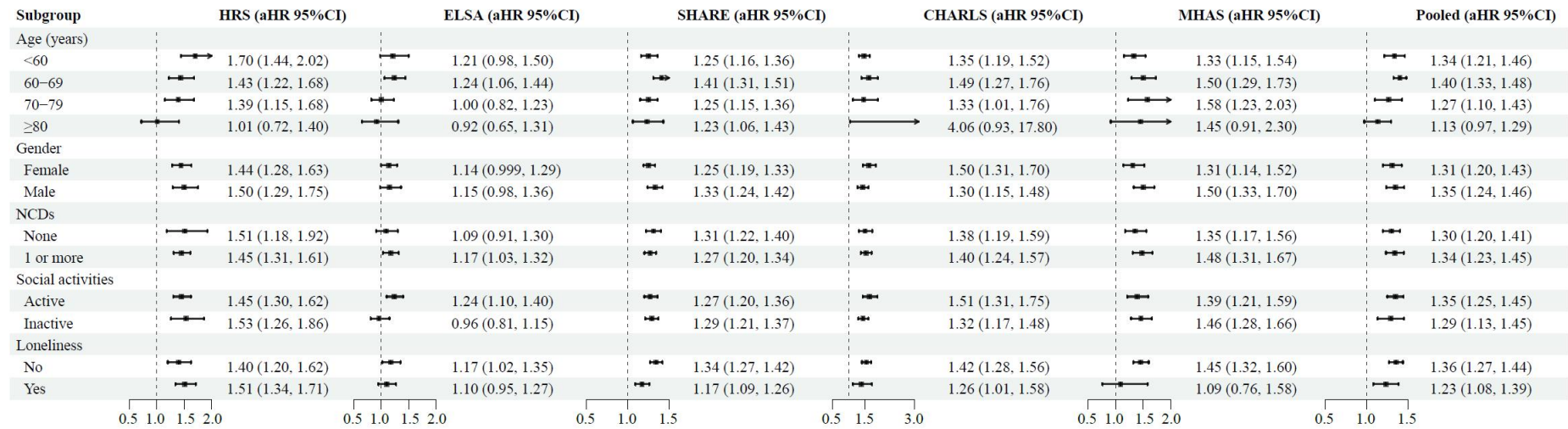
Main analysis: Model was adjusted by minimal sufficient adjusted set (MSAS), including demographic factors (age, gender, marital status), socioeconomic factors (family income, education, and labor force status), social activity, and loneliness.

We did five sensitivity analyses to test robustness of results:

- (1) We converted the continuous variable age into age group and the categorical variable loneliness into a continuous score, and performed the same MSAS control model.
- (2) We did a fixed cohort study through including only participants from the first wave of surveys within our selected time frame in each survey and used sample weights in the model.
- (3) We employed competing risks models treating death as a competing event for depression onset.
- (4) Using multiple imputation method, we imputed missing data for continuous variables by predictive mean matching method and for categorical variables by classification and regression trees method.

(5) We did full-adjusted models encompassing BMI, smoking, alcohol consumption, physical activity, and NCDs in addition to the covariates incorporated within MSAS. aHR: adjusted hazard ratio; CI: confidence interval; HRS: the Health and Retirement Study; ELSA: the English Longitudinal Study of Ageing; SHARE: the Survey of Health, Ageing and Retirement in Europe; CHARLS: the China Health and Retirement Longitudinal Study; MHAS: the Mexican Health and Ageing Study; Obs.: observations.

Figure S10: Subgroup analyses on the association of digital exclusion with the risk of depression



HRS: the Health and Retirement Study; ELSA: the English Longitudinal Study of Ageing; SHARE: the Survey of Health, Ageing and Retirement in Europe; CHARLS: the China Health and Retirement Longitudinal Study; MHAS: the Mexican Health and Ageing Study; NCDs: noncommunicable diseases.

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