Clustering of health, crime and social-welfare inequality in 4 million citizens from 2 nations

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Supplementary Information

Supplementary Methods

Study population: New Zealand Integrated Data Infrastructure

Participants in our study population were drawn from the Statistics New Zealand Integrated Data Infrastructure (NZIDI), a collection of de-identified, whole-of-population administrative data sources linked at the individual level by a common spine.[1]

The eligible population for analyses was defined as all individuals who were (a) born in New Zealand between 1950-1984, and (b) resided in the country for any period of time between the July 2006-June 2016 fiscal years (N=1,711,590; approximately age 22-66 years). We selected this age range in order to maximize representation of post-education, pre-retirement lives. July 2006 was selected for the beginning of the 10-year observation period as it represents the earliest month and year in which reliable electronic data capture was present for all administrative data sectors of interest. We divided the study population into seven four-year age-bands (Supplementary Table 10).

We excluded individuals who had (a) evidence of a death in New Zealand prior to the observation period, (b) an overseas spell spanning the entire observation period, or (c) no evidence of residence in New Zealand during the observation period (N before exclusions=2,035,530, N after exclusions (study population)=1,711,590). Information about mortality was recorded by the New Zealand Department of Internal Affairs; information about travel was recorded by the New Zealand Ministry of Business, Innovation and Employment; and information about residency was recorded in the Resident Population Table in the NZIDI.

The "resident population" restriction accounts for those who may have died prior to 1988 or emigrated prior to 1997. A person is considered resident in New Zealand if they had any indication of activity in the following administrative records: injury-insurance claims; Inland Revenue (containing all taxable income and benefits); health (including general practitioner enrollment, hospital admissions, emergency department attendances, and pharmaceutical use); and education (school enrollment, tertiary enrollment, or attainment). The resident population activity period covers two years prior to a specified

date (or dates), which for our purposes were June 30 in each of the years from 2007-2016. This method closely estimates the New Zealand population.[2]

Data analysis was approved by Statistics New Zealand-Tatauranga Aotearoa. The Health and Disability Ethics Committee classified the study as "out of scope."

Replication population: Danish nationwide registers

We replicated analyses in Danish nationwide administrative registers. The replication population covered the same birth years and 10-year observation period as the NZIDI study population, and focused on the three social, health, and justice sectors that were available to us. The replication population included 2,363,240 individuals. Data analysis was approved through a longstanding agreement between the Rockwool Foundation Research Unit and Statistics Denmark.

Dunedin Study sample

Participants were members of the Dunedin Multidisciplinary Health and Development Study, a longitudinal investigation of the health and behavior of a representative birth cohort of consecutive births between April 1972 and March 1973 in Dunedin, New Zealand.[3] The cohort (N=1,037, 52% male) was constituted at age 3 as 91% of eligible births resident in the province. The cohort represents the full range of socioeconomic status in the general population of New Zealand's South Island. On adult health, the cohort matches the New Zealand National Health and Nutrition Survey on key health indicators (e.g., body mass index, smoking, visits to the doctor). Cohort members are primarily white; approximately 7% self-identify as having any non-white ancestry, matching the South Island. Follow-up assessments were performed at ages 5, 7, 9, 11, 13, 15, 18, 21, 26, 32, and, most recently, 38 years, when 1,007 participants were still alive, with 95% retention. At each assessment wave, participants are brought to the Dunedin research unit for a full day of interviews and examinations. These data are supplemented by searches of official records and by questionnaires that are mailed, as developmentally appropriate, to parents, teachers, and peers nominated by the participants themselves. The Otago University Ethics Committee, Duke University, and King's College London provided ethical approval for the Dunedin Study and Study members gave informed consent before participating. Included in the present report were complete data

from 940 Study members (93.3% of the 1,007 participants alive at the phase-38 assessment, when administrative-record linkage was performed[4]).

Poor health, crime, and social-welfare dependency

Social welfare benefit months. In the NZIDI, information about social welfare was recorded by the New Zealand Ministry of Social Development. We obtained information about incident spells and duration of the following New Zealand government benefits: Unemployment Benefit, Unemployment Benefit Hardship, Unemployment Benefit Training, Job Seeker, Emergency Benefit, Emergency Maintenance Allowance, Invalids Benefit, Sickness Benefit, Widows Benefit, Sole Parent Support, Youth/Young Parent Payment, Domestic Purposes Benefit-Woman Alone, Domestic Purposes Benefit-Caring for Sick or Infirm, and Supported Living Payment. Only one benefit can be received at any given time. The study population accumulated 18,977,164 months of welfare payments between July 2006 and June 2016.

We monetized costs for social welfare benefits using the rates for each type of benefit received during the study period (obtained from the New Zealand Ministry of Social Development's Work and Income website[5]). For simplicity and to assume a consistent multiplier across individuals, rates assumed individuals were married, with relevant exceptions (e.g., for widow or single-parent benefits). We utilized the rates for the last fiscal year of the observation period, accounting for child dependents. $20,293,512,500 New Zealand Dollars (NZD) were spent on social welfare for the study population between July 2006 and June 2016. This cost total correlated r=0.999 with the total computed excluding child dependents.

Information about social welfare benefits was also available in the Danish registers. The replication population accumulated 31,643,808 months of welfare payments during the 10-year observation period.

Hospital-bed nights. In the NZIDI, information about admission events to public hospitals was recorded by the New Zealand Ministry of Health. We did not include information about admission events to private hospitals because data from private hospitals in New Zealand are often incomplete due to the

voluntary nature of returns. This is not likely to have significantly impacted our results, as approximately 5% of New Zealand hospitalizations are estimated to occur in private hospitals, and most are for elective surgeries and thus less relevant to concerns about costs to society and government.[6] The study population accumulated 6,469,382 bed-nights in public hospitals between July 2006 and June 2016. Length-of-stay was adjusted for healthy maternity births by subtracting five days (the 90th percentile for the number of days spent in hospital for birth events) from the length-of-stay for all birth events. Women with a birth event lasting less than five days were assigned a length-of-stay of zero days.

We monetized costs for hospitalizations by calculating the number of government dollars spent on public hospital admissions during the observation period. Each admission to a public hospital in New Zealand is assigned a "costweight" based on the length-of-stay and complexity of the admission, where a costweight of 1 indicates an "average-cost" admission, a costweight of 0.5 costs half as much, etc. To assign costs equivalently across the observation period, costweights were multiplied by the unit purchase cost for the final fiscal year (2015/16: $4,751.58 NZD[7]). $11,323,466,000 NZD were spent on bed-nights in public hospitals for the study population between July 2006 and June 2016.

Information about admission events to public hospitals was also available in the Danish registers. The replication population accumulated 10,250,365 bed-nights in public hospitals (length-of-stay adjusted for healthy maternity births) during the 10-year observation period.

Prescription drug fills. In the NZIDI, information about prescription drugs filled by pharmacists was recorded by the New Zealand Pharmaceutical Management Agency (PHARMAC). PHARMAC selects and purchases, on behalf of District Health Boards, medicines and related products subsidized for community use. This database represents a record of requests from pharmacists for payment of subsidies associated with prescriptions. Any medications dispensed that are not on the PHARMAC subsidized list (all common medications are on the list) will not be captured in the data, but all medications subsidized by the New Zealand government will be captured. Drugs administered during hospital stays are not recorded as prescription fills. The study population filled 149,188,627 prescriptions between July 2006 and June 2016.

We monetized costs for prescription drug fills by summing the patient contribution and government subsidy for each prescription filled during the observation period. $3,173,769,000 NZD were spent on prescription fills for the study population between July 2006 and June 2016.

Injury insurance claims. In the NZIDI, information about insurance claims for accidents and injuries was recorded by the Accident Compensation Corporation (ACC), the national provider of comprehensive, no-fault personal injury coverage for New Zealanders. Anyone who has experienced an injury is eligible for coverage, regardless of how it occurred. ACC covers much of the costs of emergency provision in hospitals, all or some of the costs of immediate care and rehabilitation, and costs to the person associated with income maintenance or life adaptations. The study population made 5,011,953 accepted ACC claims between July 2006 and June 2016.

We monetized costs for injury-insurance claims by calculating the number of government dollars spent on claims made during the observation period. $6,325,665,800 NZD were spent on ACC claims for the study population between July 2006 and June 2016.

Convictions for crime. In the NZIDI, information about criminal convictions was recorded by the New Zealand Ministry of Justice. Convictions included crimes of force, fraud, theft, drugs, and vice. The study population accumulated 721,539 convictions for adult crimes (excluding traffic offenses) between July 2006 and June 2016.

We did not monetize crime for two reasons. First, crime entails intangible costs that are difficult to estimate.[8] Second, any method is likely to significantly underestimate costs, as many crimes (e.g., thefts, drug offenses) are not typically included in cost studies.[9] Note, however, that although we did not monetize crime costs, only 10.7% of the study population had a conviction during the 10-year observation period, indicating that the 10% highest-need users accounted for virtually all of the dollars spent in this sector.

Information about criminal convictions was also available in the Danish registers. The replication population accumulated 391,616 convictions for adult crimes (excluding traffic offenses) during the 10-year observation period.

Note. All of the following measures from the Dunedin Study have been previously published.

Human-capital factors

Young-adult educational attainment. Information about educational attainment was available in both the NZIDI (for 78.9% of the study population who provided education data in the 2013 census) and the Dunedin cohort. 19.1% of the NZIDI study population left secondary school early without any qualifications; the percentage of individuals without qualifications was higher in older than younger age-bands (Supplementary Table 11). 14.9% of the Dunedin Study sample left secondary school early without any qualifications, which closely matched the rate of 14.7% for the NZIDI population born in the same years.

Adolescent mental health. Psychiatric diagnoses at 11, 13, and 15 years of age were assessed in the Dunedin cohort using the Diagnostic Interview Schedule for Children,[10] following the then-current DSM-III criteria.[11] Study members were defined as having a diagnosis during adolescence if they met full diagnostic criteria for depression, anxiety, conduct disorder, or attention-deficit/hyperactivity disorder. 35.1% of the Dunedin Study sample met diagnostic criteria for a psychiatric disorder,[12] which matches the prevalence in United States epidemiological samples.[13]

Childhood brain health. At age 3 years, each child in the Dunedin cohort participated in a 45-minute examination that included assessments of neurological soft signs, intelligence, receptive language, and motor skills, and afterwards the examiners (having no prior knowledge of the child) rated each child's behavior (all described in Supplementary Table 1). Using this information, we created a summary factor score via confirmatory factor analysis which we termed brain health, a global index of the child's early neurocognitive status.[4] The model fit the data well: χ^2(N=1035, df=5)=6.459, p=0.264, CFI=.999, TLI=.997, RMSEA=.017. Factor scores were output and standardized to M=100, SD=15.

Childhood physical health

We measured Dunedin participants' childhood physical health using a composite that included repeated measures of adiposity, blood pressure, lung function, motor function, and diseases and injuries

taken when study members were age 3-11 years. These assessments have been previously described in detail.[19] The composite was standardized to M=0, SD=1.

Life satisfaction

At age 38, Dunedin cohort participants completed the 5-item Satisfaction With Life Scale.[20] Participants were asked to rate how strongly they agreed with each of the following statements, on a 5-point scale (1="strongly disagree" and 5="strongly agree"): "In most ways my life is close to ideal"; "The conditions of my life are excellent"; "I am satisfied with my life"; "So far I have gotten the important things I want in life"; "If I could live my life over, I would change almost nothing." The items were summed and the resulting scale was standardized to M=0, SD=1. The scale was approximately symmetrically distributed (skewness=-0.59).

Statistical analysis

Matching procedures. In the NZIDI study population, individuals were matched to administrative databases using a common spine.[1] In the Danish replication population, individuals were matched to administrative databases using personal identification numbers assigned through the Danish Civil Registration System.[21]

In the Dunedin Study sample, matching was completed by a senior Unit staff member working onsite at each agency, alongside dedicated agency staff. Because the Dunedin Study has collected so much information about Study participants, it was possible to carefully evaluate and resolve any uncertain matches (for instance, by using participants' full names (including name changes), dates of birth, complete residential histories, and employment status). Further, because the sample size is under 1,000, we were able to give individual attention to every match. All match processes stipulated that no identifying information was retained by the matching agency and all Study member data were deleted at the end of the match process (i.e., agencies did not retain Study data). Matching was completed following the end of the age-38 assessment, which had an end date of March 31, 2012. Thus, the coverage periods between the nationwide NZIDI analysis and the Dunedin cohort analysis do not overlap perfectly.

Death and outmigration. Individuals who died or traveled outside of New Zealand during our 10-year observation period had reduced time during which they were eligible to appear in New Zealand government records. Failing to account for these differences in exposure time could lead to biased estimates because some individuals whose activity went unobserved would be improperly coded as "non-users" of public services, but they would have used these services if they had been alive or in the country. Information about mortality was recorded by the New Zealand Department of Internal Affairs and information about travel was recorded by the New Zealand Ministry of Business, Innovation and Employment. Using this information, we accounted for individual differences in "exposure time" by weighting the data based on time spent alive and in the country. For instance, an individual who was alive and in New Zealand during the entire 10-year observation period was assigned a weight of 1.0, while someone who was alive and in the country during only the first five years was assigned a weight of 0.5. Weighted frequencies for all age-bands and the study population are presented in Supplementary Table 10.

Data for the Danish replication population were also weighted. Given Denmark's low rate of out-migration, the weighted and unweighted population frequencies were similar (weighted N=2,290,048).

Cumulative distributions. We began by examining the cumulative distributions of events in each of the five health and social sectors in the study population. Using these distributions, we assessed the degree of inequality in each sector by calculating the Gini coefficient, an economic measure of statistical dispersion traditionally used to index income inequality.[22,23] Following analyses in the study population, we assessed the degree of inequality in each sector by age-band and sex, using age-band and sex-specific distributions.

High-need group membership. In all subsequent analyses, we operationally defined a high-need group in each sector as 10% of the study population who accounted for the most disproportionate share of use-events in that sector. This 10% cut-point was based on the sector with the lowest prevalence of use (criminal convictions) and was applied in all sectors to allow comparisons across sectors. We tested whether high-need users in one sector were likely to be high-need users in multiple sectors using two

methods. First, we added up (0-5) the number of high-need groups to which each individual belonged, and tested whether the distribution of high-need users across multiple sectors deviated from the expectation of a random distribution. Second, we used logistic regression to predict high-need group membership in one sector from high-need group membership in another sector. Analyses were conducted within the study population and separately by age-band and sex.

Replication in Danish nationwide records. In the Danish replication population, we calculated Gini coefficients, defined parallel high-need groups, and calculated odds ratios for the overlap among the social-welfare, hospital, and criminal-offending sectors. (Because only 7.7% of the replication population had a criminal conviction during the observation period, the high-need group in this sector comprised the top 7.7% rather than the top 10% of users.)

Characterizing high-need groups. In the NZIDI and Dunedin datasets, we used negative binomial regression models with incidence rate ratios to test whether early human-capital factors (young-adult educational attainment, adolescent mental health, and childhood brain health) predicted the number of high-need groups to which an individual belonged. We used ordinary least squares linear regression to test whether high-need group membership (entered as an ordinal predictor) was associated with life satisfaction.

In the NZIDI dataset (weighted for time spent outside New Zealand or deceased), models using the total study population controlled for sex and age-band; models within age-bands controlled for sex. In the Dunedin cohort, models controlled for sex and time spent outside New Zealand.

Random-rounding. Per the confidentiality rules of Statistics New Zealand, frequencies/counts were randomly rounded to a base of three and dollar values were rounded to the nearest 100 for the NZIDI data.

Preregistration. The project and analysis plan were preregistered (2018; https://cdm20045.contentdm.oclc.org/digital/collection/p20045coll17; https://sites.google.com/site/dunedineriskconceptpapers/home/dunedin-approved).

Supplementary Results

Comparing observed to expected frequencies for high-need group membership in the NZIDI study population.

The distribution of high-need individuals across multiple sectors deviated from the expectation of a random distribution ($\chi^2_{(5)}$=291476.55, p<0.001), with excesses at the two tails. That is, there are more individuals than expected who do not belong to any high-need group and there are more individuals than expected who belong to multiple high-need groups. The expected distribution is based on the assumption that the high-need groups were independent and did not overlap beyond chance. The observed/expected ratios in each of the six cells are: 1.12, 0.71, 1.06, 3.11, 13.21, 66.77 (Supplementary Table 2).

Supplementary Tables

Supplementary Table 1. Measures and tests included in the childhood brain health factor.

Measure / Test	Description
Neurologic Soft Signs	At age three years, each child was examined by a pediatric neurologist for neurologic signs, including assessment of motility, passive movements, reflexes, facial musculature, strabismus, nystagmus, foot posture, and gait, based on procedures described by Touwen and Prechtl.[14]
Peabody Picture Vocabulary Test	Intelligence was assessed at age three with the Peabody Picture Vocabulary test.[15]
Receptive Language	Receptive language was assessed at age three using the Reynell Developmental Language Scales.[16]
Motor Development	Motor development was assessed at age three years with the Bailey Motor Scales.[17]
Lack of Control	Following the testing, each examiner rated the child's lack of control in the testing session, yielding a behavioral style factor, labeled Lack of Control,[18] which characterized children who at age three years were labile, had low frustration tolerance, lacked reserve, were resistant, restless, impulsive, required attention, and lacked persistence in reaching goals.

Supplementary Table 2. Observed v. expected frequencies for high-need group membership in the NZIDI.

	Frequencies[a]	
Number of high-need groups	**Observed**	**Expected if Random**
0	877,257	785,630
1	325,137	460,371
2	114,705	107,834
3	39,213	12,621
4	9,747	738
5	1,152	17

[a]Weighted counts. Randomly rounded to a base of three, per the confidentiality rules of Statistics New Zealand.

Supplementary Table 3. Aggregation of poor health, crime, and social-welfare dependency in the total study population.

	Injury claims	Social welfare	Hospital nights	Prescription fills
Social welfare	0.81 [0.80 – 0.83]			
Hospital nights	1.56 [1.54 – 1.58]	3.94 [3.89 – 4.00]		
Prescription fills	1.67 [1.64 – 1.70]	5.58 [5.51 – 5.66]	7.69 [7.59 – 7.78]	
Crime	1.32 [1.29 – 1.34]	5.35 [5.28 – 5.42]	1.93 [1.90 – 1.96]	1.34 [1.32 – 1.36]

Note. Estimates are odds ratios [and 95% confidence intervals]. Estimates indicate the odds of belonging to a high-need group in one sector, as a function of belonging to a high-need group in another sector. P-values for all associations are <0.001.

Supplementary Table 4. Aggregation of poor health, crime, and social-welfare dependency by age and sex.

Age band 1

Born 1980-84 Age 22-36y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		3.15 [2.98 – 3.32]	2.98 [2.82 – 3.15]	0.86 [0.80 – 0.92]	8.96 [8.53 – 9.42]
Hospital nights	4.32 [4.11 – 4.54]		5.29 [5.03 – 5.57]	1.91 [1.81 – 2.01]	2.28 [2.15 – 2.41]
Prescription fills	5.52 [5.25 – 5.81]	6.08 [5.79 – 6.39]		2.95 [2.80 – 3.10]	1.60 [1.50 – 1.70]
Injury claims	0.66 [0.61 – 0.72]	2.02 [1.91 – 2.14]	1.67 [1.57 – 1.77]		1.20 [1.13 – 1.28]
Crime	9.19 [8.76 – 9.65]	3.11 [2.96 – 3.27]	1.59 [1.50 – 1.69]	1.22 [1.14 – 1.30]	

Age band 2

Born 1975-79 Age 27-41y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		2.85 [2.70 – 3.01]	3.83 [3.64 – 4.03]	0.97 [0.91 – 1.04]	9.62 [9.13 – 10.14]
Hospital nights	4.37 [4.16 – 4.60]		5.79 [5.51 – 6.08]	1.81 [1.71 – 1.92]	2.21 [2.08 – 2.34]
Prescription fills	6.71 [6.38 – 7.05]	6.47 [6.16 – 6.79]		2.84 [2.69 – 3.00]	2.01 [1.88 – 2.14]
Injury claims	0.69 [0.64 – 0.75]	1.88 [1.78 – 1.99]	1.54 [1.45 – 1.63]		1.16 [1.07 – 1.24]
Crime	10.17 [9.68 – 10.68]	3.17 [3.02 – 3.34]	1.99 [1.88 – 2.11]	1.19 [1.12 – 1.27]	

Age band 3

Born 1970-74 Age 32-46y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		3.25 [3.10 – 3.41]	5.05 [4.82 – 5.29]	0.91 [0.85 – 0.97]	9.32 [8.85 – 9.80]
Hospital nights	4.56 [4.36 – 4.78]		6.22 [5.95 – 6.51]	1.76 [1.67 – 1.85]	2.41 [2.28 – 2.56]
Prescription fills	7.12 [6.79 – 7.46]	7.37 [7.04 – 7.71]		2.39 [2.27 – 2.51]	2.35 [2.21 – 2.49]
Injury claims	0.67 [0.62 – 0.73]	1.69 [1.60 – 1.79]	1.57 [1.48 – 1.67]		1.06 [0.99 – 1.14]
Crime	9.33 [8.92 – 9.76]	2.98 [2.84 – 3.13]	2.14 [2.03 – 2.25]	1.08 [1.02 – 1.15]	

Age band 4

Born 1965-69 Age 37-51y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		4.12 [3.93 – 4.33]	5.80 [5.53– 6.08]	0.97 [0.92 – 1.04]	8.28 [7.84 – 8.74]
Hospital nights	4.66 [4.44 – 4.88]		8.43 [8.05 – 8.82]	1.74 [1.65 – 1.83]	2.64 [2.48 – 2.81]
Prescription fills	7.61 [7.27 – 7.98]	7.75 [7.41 – 8.12]		2.22 [2.11 – 2.34]	2.36 [2.22 – 2.52]
Injury claims	0.67 [0.63 – 0.72]	1.53 [1.45 – 1.61]	1.44 [1.36 – 1.52]		1.10 [1.02 – 1.18]
Crime	6.50 [6.23 – 6.78]	2.51 [2.40 – 2.62]	1.90 [1.81 – 1.99]	0.96 [0.91 – 1.01]	

Age band 5

Born 1960-64 Age 42-56y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		4.34 [4.14 – 4.55]	6.66 [6.36 – 6.98]	1.06 [0.99 – 1.12]	7.70 [7.25 – 8.19]
Hospital nights	4.69 [4.47 – 4.91]		8.58 [8.20 – 8.98]	1.71 [1.62 – 1.80]	2.42 [2.25 – 2.60]
Prescription fills	7.29 [6.96 – 7.63]	8.63 [8.25 – 9.03]		2.15 [2.05 – 2.27]	2.23 [2.07 – 2.40]
Injury claims	0.69 [0.64 – 0.74]	1.43 [1.35 – 1.51]	1.40 [1.32 – 1.48]		1.10 [1.01 – 1.20]
Crime	6.05 [5.79 – 6.32]	2.41 [2.29 – 2.52]	1.81 [1.72 – 1.90]	1.01 [0.95 – 1.06]	

Age band 6

Born 1955-59 Age 47-61y

	Social welfare	Hospital nights	Prescription fills	Injury claims	Crime
Social welfare		4.68 [4.44 – 4.93]	7.02 [6.67 – 7.39]	1.28 [1.20 – 1.37]	7.30 [6.73 – 7.93]
Hospital nights	4.60 [4.38 – 4.83]		9.00 [8.55 – 9.74]	1.65 [1.56 – 1.76]	2.60 [2.36 – 2.86]
Prescription fills	6.98 [6.65 – 7.32]	8.36 [7.97 – 8.76]		2.29 [2.16 – 2.42]	2.37 [2.15 – 2.62]
Injury claims	0.74 [0.69 – 0.80]	1.44 [1.35 – 1.53]	1.49 [1.41 – 1.59]		1.23 [1.10 – 1.38]
Crime	5.81 [5.53 – 6.11]	2.08 [1.97 – 2.21]	1.72 [1.62 – 1.83]	1.00 [0.93 – 1.07]	

Supplementary Table 4 continued.

	Age band 7 Born 1950-54 Age 52-66y				
	Social welfare	**Hospital nights**	**Prescription fills**	**Injury claims**	**Crime**
Social welfare		4.35 [4.11 – 4.61]	7.06 [6.67 – 7.47]	1.31 [1.22 – 1.41]	5.42 [4.81 – 6.10]
Hospital nights	4.76 [4.51 – 5.01]		9.71 [9.19 – 10.26]	1.65 [1.54 – 1.76]	2.22 [1.93 – 2.56]
Prescription fills	7.03 [6.67 – 7.40]	8.33 [7.92 – 8.77]		2.29 [2.15 – 2.44]	2.09 [1.80 – 2.41]
Injury claims	0.78 [0.72 – 0.84]	1.43 [1.34 – 1.52]	1.58 [1.49 – 1.68]		1.32 [1.12 – 1.56]
Crime	5.38 [5.06 – 5.71]	1.94 [1.80 – 2.08]	1.67 [1.55 – 1.80]	0.99 [0.91 – 1.08]	

Note. Estimates are odds ratios [and 95% confidence intervals]. Estimates indicate the odds of belonging to a high-need group in one sector, as a function of belonging to a high-need group in another sector. Estimates for males are presented below the diagonal in blue and estimates for females are presented above the diagonal in pink. In males, p-values for all associations are <0.001, with the exception of the relation between injury claims and crime in age bands 3 through 7 (band 3: p=0.012, band 4: p=0.125, band 5: p=0.735, band 6: p=0.903, band 7: p=0.829). In females, p-values for all associations are <0.001, with the exception of the relation between injury claims and social welfare in age bands 2 through 5 (band 2: p=0.378, band 3: p=0.005, band 4: p=0.335, band 5: p=0.064) and the relation between injury claims and crime in age bands 3 through 5 and 7 (band 3: p=0.105, band 4: p=0.010, band 5: p=0.030, band 7: p=0.001).

Supplementary Table 5. Distribution of total New Zealand dollars spent on health- and social-service provision, across the different levels of high-need group membership.

Number of high-need groups	Total costs in 10-year observation period	Annual cost per person
0	8,064,108,000	900
1	13,314,459,400	4,100
2	10,873,069,200	9,500
3+	8,864,776,600	22,600

Note. Costs were not available for crime. Dollar values randomly rounded to the nearest 100, per the confidentiality rules of Statistics New Zealand.

Supplementary Table 6. Distributions of high-need group membership in the NZIDI study population and the Dunedin cohort.

Number of high-need groups	NZIDI (N=1,367,211[a])	Dunedin (N=940)
	%	
0	64.2	68.1
1	23.8	19.7
2	8.4	7.2
3	2.9	3.6
4	0.7	1.1
5	0.1	0.3

[a]Weighted N. Randomly rounded to a base of three, per the confidentiality rules of Statistics New Zealand.

Supplementary Table 7. Effect sizes for associations between human-capital factors and the number of high-need groups to which individuals belonged.

Human-capital factor	Correlation coefficient	Cohen's *d*
Childhood brain health	-0.24	-0.47
Adolescent mental-health diagnosis	0.28	0.58
Low educational attainment	0.32	0.68
Poor childhood physical health	0.12	0.25

Note. Effect sizes were derived from the negative-binomial regression models. The corresponding incidence rate ratios were as follows (see also Figure 6 in the main text): brain health = 0.98, 95% confidence interval [0.97, 0.98], p<0.001; mental health = 2.46 [2.00, 3.02], p<0.001; educational attainment = 2.92 [2.36, 3.61], p<0.001; physical health = 1.23 [1.10, 1.36], p<0.001. Associations are adjusted for sex and time spent outside New Zealand. Correlation coefficients of 0.10, 0.30, and 0.50 indicate small, medium, and large effects, respectively.[24] Cohen's *d* values of 0.20, 0.50, and 0.80 indicate small, medium, and large effects, respectively.[24]

Supplementary Table 8. Associations between high-need group membership in the social-welfare sector and high-need group membership in other sectors, (a) including all benefits, (b) after removing sickness and disability benefits, and (c) including only sickness and disability benefits.

	All benefits included	Sickness and disability benefits excluded	Only sickness and disability benefits included
Hospital nights	3.94 [3.89 – 4.00]	3.53 [3.49 – 3.58]	4.23 [4.17 – 4.30]
Prescription fills	5.58 [5.51 – 5.66]	4.89 [4.82 – 4.96]	3.37 [3.32 – 3.43]
Crime	5.35 [5.28 – 5.42]	3.75 [3.70 – 3.80]	6.63 [6.54 – 6.73]
Injury claims	0.81 [0.80 – 0.83]	0.80 [0.78 – 0.81]	1.49 [1.46 – 1.52]

Note. Estimates are odds ratios [and 95% confidence intervals]. P-values for all associations are <0.001.

Supplementary Table 9. Distribution of high-need group membership across sectors, among individuals who were members of three or more high-need groups (N=50,112[a]).

	%
Social welfare (including sickness and disability)	77.3
Social welfare (excluding sickness and disability)	57.8
Hospital nights	82.1
Prescription fills	76.4
Injury claims	36.2
Crime	52.1

[a]Weighted N. Randomly rounded to a base of three, per the confidentiality rules of Statistics New Zealand.

Supplementary Table 10. New Zealand study population.

	Age band 1 Born 1980-84	Age band 2 Born 1975-79	Age band 3 Born 1970-74	Age band 4 Born 1965-69	Age band 5 Born 1960-64	Age band 6 Born 1955-59	Age band 7 Born 1950-54	Total population Born 1950-84
Age during observation period	**Age 22-36y**	**Age 27-41y**	**Age 32-46y**	**Age 37-51y**	**Age 42-56y**	**Age 47-61y**	**Age 52-66y**	**Age 22-66y**
Unweighted N	235,293	240,558	273,279	263,010	267,546	234,399	197,502	1,711,590
Weighted N[a]	182,262	188,484	217,521	212,814	216,882	189,267	159,981	1,367,211
Mean years of follow-up[b]	7.75	7.84	7.96	8.09	8.11	8.07	8.10	7.99

Note. Per the confidentiality rules of Statistics New Zealand, counts were randomly rounded to a base of three.
[a]Weighted for time spent alive and in New Zealand.
[b]Mean number of years during which individuals were alive and in New Zealand.

Supplementary Table 11. Educational attainment in the NZIDI.

	Age band 1 Born 1980-84 Age 22-36y N=131,322	Age band 2 Born 1975-79 Age 27-41y N=144,579	Age band 3 Born 1970-74 Age 32-46y N=173,766	Age band 4 Born 1965-69 Age 37-51y N=170,646	Age band 5 Born 1960-64 Age 42-56y N=174,432	Age band 6 Born 1955-59 Age 47-61y N=153,000	Age band 7 Born 1950-54 Age 52-66y N=130,572	Total population Born 1950-84 Age 22-66y N=1,078,317
	%							
No qualifications	15.8	14.1	14.7[a]	19.3	20.7	22.6	27.3	19.1

Note. Ns are weighted and indicate individuals in the study population who provided information concerning educational qualifications in the 2013 census. Ns were randomly rounded to a base of three, per the confidentiality rules of Statistics New Zealand.

[a]The estimate for the NZIDI 1970-74-born age band (14.7%) was very similar to the estimate for the Dunedin 1972-73 cohort (14.9%).

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