Supporting Information for

Generational differences in mental health trends in the twenty-first century

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This PDF file includes:

Supporting text
Figs. S1 to S8
Table S1
Legend for Dataset S1
SI References

Other supporting materials for this manuscript include the following:

Dataset S1

Supporting Information Text

Sensitivity analyses

Alternate cohort definitions. The birth cohort definitions reported in the main text were aligned with the calendar decade (e.g., the 1990s birth cohort included people born between 1990 to 1999, inclusive). We also tested other cohort definitions to determine whether the reported results generalized and were not specific to this initial choice of cohort definition.

We examined four sequential new cohort schemes, in which the starting point for each cohort was defined by birth-years one year earlier than the previous scheme. Thus the first scheme used a range of years that commenced and ended one year earlier than the original definition (e.g., the youngest cohort became a "1989:1998" cohort, and the oldest cohort became a "1939:1948" cohort). The fourth and final scheme used a cohort definition that commenced and ended four years earlier than the original definition (e.g., the youngest cohort became a "1986:1995" cohort, the oldest cohort became a "1936:1945" cohort).

For each alternative cohort scheme, we repeated the main analysis and calculated the difference smooths between each cohort and the next oldest cohort using the same model as reported in the main text. Figure S1 presents the resulting difference smooths in a 5-by-5 multipanel figure to allow the reader to compare and contrast the impact of alternative cohort definitions on the main result.

Each difference smooth in Figure S1 represents the mean centred difference between the titular cohort and the next oldest cohort, as in the main text. For example, the 1990s difference smooth represents the difference between the 1990s cohort and the 1980s cohort; the 1989:1998 difference smooth represents the difference between the 1989:1998 cohort and the 1979:1988 cohort, and so on. In each column the difference smooth is steepest for the youngest cohort in the top row, and flat or relatively flat for the oldest cohorts in the bottom row. Thus each column indicates greater (relative) declines in mental health with age for younger cohorts relative to older cohorts, regardless of cohort definition.

Where differences between definitions (columns) do appear, it mostly represents the movement of people in each cohort shifting to the next (younger) cohort as the cohort definition changes. However this shift does not impact the flattening pattern occurring within each column, confirming that our specific cohort definition is not driving the primary results of interest.

Period effects. Period effects refer to variance over time that is common across all age groups and cohorts, due to population-wide events such as the Global Financial Crisis (GFC) in 2008 or the COVID-19 pandemic that started in 2020. We estimated the nonlinear effect of period over the complete set of survey years (2000 to 2020) as a smooth term in a model by age-group:

$$
\begin{aligned}
y_{it} &= \beta_k(\text{age-group}_{it}) + f(year_{it}) + f_{[k]}(year_{it}) + \zeta_i + \epsilon_{it} \\
\epsilon_{it} &\sim N(0, \sigma^2)
\end{aligned}
$$

Where y_{it} is the continuous MHI-5 score for each person i in each year of the survey $t = 1...20$; β_k is the mean MHI-5 estimate for each $k = 1...6$ age-group, after accounting for variations in trend over year; $f(year)$ is a smooth function of year (period effect) and $f_{[k]}$ are the smooth functions over year for each age-group.

The smooth effect of period (after accounting for nonlinear age effects) is shown as a dotted line in the left panel of Figure 1 in the main text. The dotted line in the left panel of Figure 1 (main text) shows a slow decline in average MHI-5 scores from 2007 but which becomes more exaggerated from around 2017. However the trajectory is not the same across all age-groups, indicated by the deviation of the age-group smooths (colored lines) from the dotted line.

We detrended the linear period effect from the main results by including a linear term for period, and estimating the smooth differences in mental health between adjacent cohorts (Figure S2). The resulting cohort smooths shown in the left panels of Figure S2 no longer show the common negative trend in mental health over age. However the difference smooths in the right panels still show the negative interaction is present in younger cohorts relative to older cohorts.

Psychological distress. K10 scores (psychological distress: where higher scores indicate greater distress) were collected in alternate years from 2007 to 2019 in HILDA. We modelled the age and cohort effects in the K10 scores in a GAMM model similar to that described for MHI-5 scores. The corresponding trajectories for each cohort are shown in Figure S3 and confirm psychological distress was higher for more recent cohorts than earlier cohorts at the same age, consistent with the main results reported for mental health (MHI-5 scores).

Prevalence of mental illness. The MHI-5 has good psychometric properties when identifying DSM-V disorders in a community sample (1) and it has proven useful as a screening tool for depression and anxiety (2). While the MHI-5 is not a diagnostic instrument, Berwick et al (3) and Ware et al (4) showed that the optimal cut-off for detecting depression or anxiety is 52 or less, on the 0-100 scale. This has thus become a frequently used MHI-5 cut-off point to identify risk of mental illness (1, 5–9), and we follow that convention and use the same cut-off to determine whether a person is at risk of mental illness or not.

We modelled the prevalence of mental illness for each age-group and cohort in a GAMM model similar to that described for MHI-5 scores in the main text, with the distributional assumptions updated to reflect the binary outcome. The results are presented in Figure S4 and confirm the prevalence of mental illness was higher for more recent cohorts than earlier cohorts at the same age, consistent with the main results for mental health (MHI-5 scores).

Gender differences. The birth cohort trajectories in mental health (MHI-5 scores) over time were modelled separately for men and women. The results are shown in Figure S5 and confirm that while women had lower average MHI-5 scores, men and women had similar trajectory differences between cohorts.

Excluding the top-up sample. We confirmed the declining mental health trajectories were not due to the addition of new respondents to the HILDA Survey. To maintain the representativeness of the survey over time, the HILDA Survey added new respondents in 2011 via a top-up sample. This was also around the same time that declines in mental health can be observed in Figure 1, left panel of the main text. We conducted an analysis excluding the top-up sample members to confirm the declining mental health trajectories were not driven by the new respondents in the top-up sample. The results shown in Figure S6 are consistent with the results reported in the main text.

Social demand effects. Individuals may conceal poor mental health when surveyed by a unfamiliar interviewer due to unmeasured social demand characteristics. The HILDA Survey assigns the same interviewer to households over time so this effect can be ameliorated by excluding the first survey from each person. Note the MHI-5 is part of the self-complete questionnaire (SCQ) so no interviewer is present and we expect social demand characteristics to be low. The mental health trajectories after excluding the first interview are shown in Figure S7 and the results confirm that social demand characteristics did not substantially change the cohort trajectories.

Attrition effects. We examined the effect of panel attrition (i.e., missingness) on the main results due to concerns that the probability of attrition from the panel may vary with the experience of mental health. For instance, if people with deteriorating mental health were more likely to leave the panel, this could produce a bias since people with lower mental health are not likely to be observed or measured in the results. If that bias varies with age or cohort such that older people or earlier cohorts are more likely to be missing in the data when their mental health declines, then that could produce a pattern of results consistent with the results we observed (i.e., a confound).

We examined the effect of attrition in two different ways. In the first approach, we modelled the dependency between mental health and missingness in the following year, including any interactions with cohort. If the dependency between mental health and subsequent missingness varies by cohort such that older cohorts were more likely to be missing with declines in mental health, then that could contribute to the different cohort trajectories reported in the main analysis (i.e., a confound). Thus we test the interaction between mental health and cohort on missingness, and report the marginal effect of MHI-5 score on probability of missingness for each cohort. To identify the source of the interaction, in a post-estimation procedure we compared the estimated dependencies (βs) for each cohort with the earlier reference cohort. The post-estimation comparisons were adjusted for multiple comparisons (Tukey), and standard errors along with p-values are reported.

To model the dependency between mental health and attrition in the first approach, we constructed a dummy variable indicating whether the MHI-5 score was missing the following year, for each individual and entered it into the model as the outcome (y) variable. Note that this indicator cannot be calculated for the final wave used in our analysis (Wave 20), as we cannot determine whether the MHI-5 score will or will not be missing in the subsequent survey wave. On average, in about 5 percent of person-year observations ($n = 13,061$) the MHI-5 score was missing in the following survey wave. The missingness dummy was regressed on MHI-5 scores in a multilevel model with random intercepts for person and year dummies to estimate the total dependency between missingness and mental health. We also included interaction terms between MHI-5 scores and each birth cohort, and in a post-estimation procedure compared the dependency between mental health and missingness between adjacent cohorts.

The results showed that a model including MHI-5 scores predicted significantly more variance in missingness than a null model ($\chi^2 = 163.14$, $p < .001$), confirming a dependency existed between mental health and missingness. This is consistent with previous research showing a small but significant dependency existed (OR = 0.992) (c.f., OR = 0.991, (10)). The dependency with mental health also interacted with birth cohort ($\chi^2 = 59.77$, $p < .001$), such that missingness was more likely with decreases in mental health among earlier cohorts (i.e., consistent with a confound). Table S1 shows the odds ratio of missingness for a decrease in MHI-5 score (c.f. OR column, Table S1), as well as the post-estimation comparison with the prior cohort (c.f. Difference column, Table S1). The results show the difference between adjacent cohorts was very small (Differences $< .01$ in OR units) and mostly non-significant. Only the difference between the 60s and 50s cohort reached statistical significance.

In the second approach we re-estimated the smooth differences between cohorts after excluding those people who final observation was missing (i.e., due to attrition). To do this we identified among the subset of people with missing data any person who did not return after their most recent missing interview, as a proxy of attrition. We re-conducted the main analysis of smooth difference trends after excluding the attrition subset. Figure S8 shows that excluding persons who eventually are lost to attrition did not change the differences between cohorts, and mental health was lower in more recent cohort relative to earlier cohorts at the same age.

Overall the results indicate a dependency between poorer mental health and missingness exists, however it is small and does not appear to explain the differences between cohort trajectories we observe in the main analysis.

Results

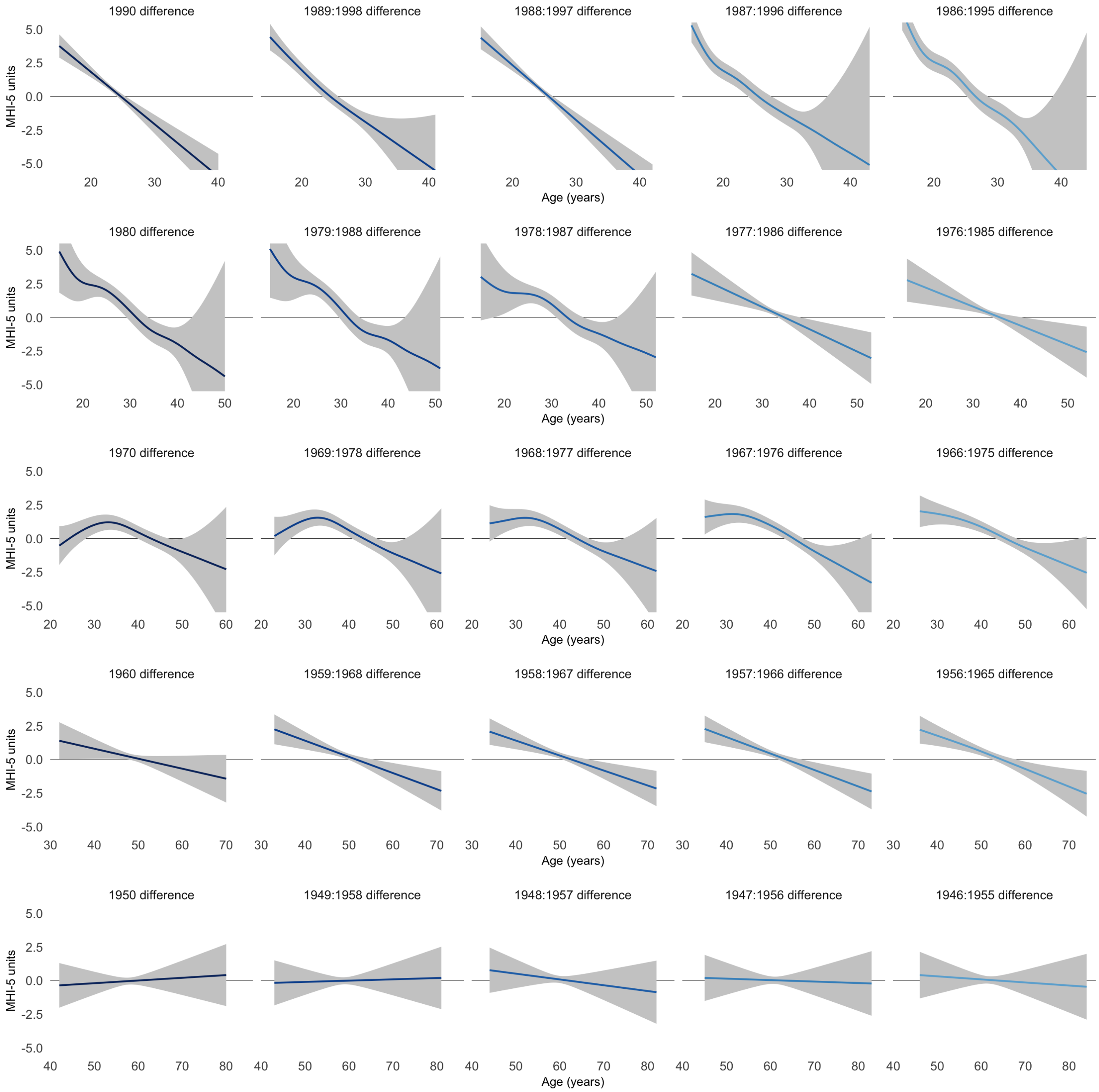

Fig. S1. Centered cohort difference smooths (relative to the subsequent older cohort). Cohorts arranged by row (top to bottom from youngest to oldest) and definitions by column (left to right from original to earliest).

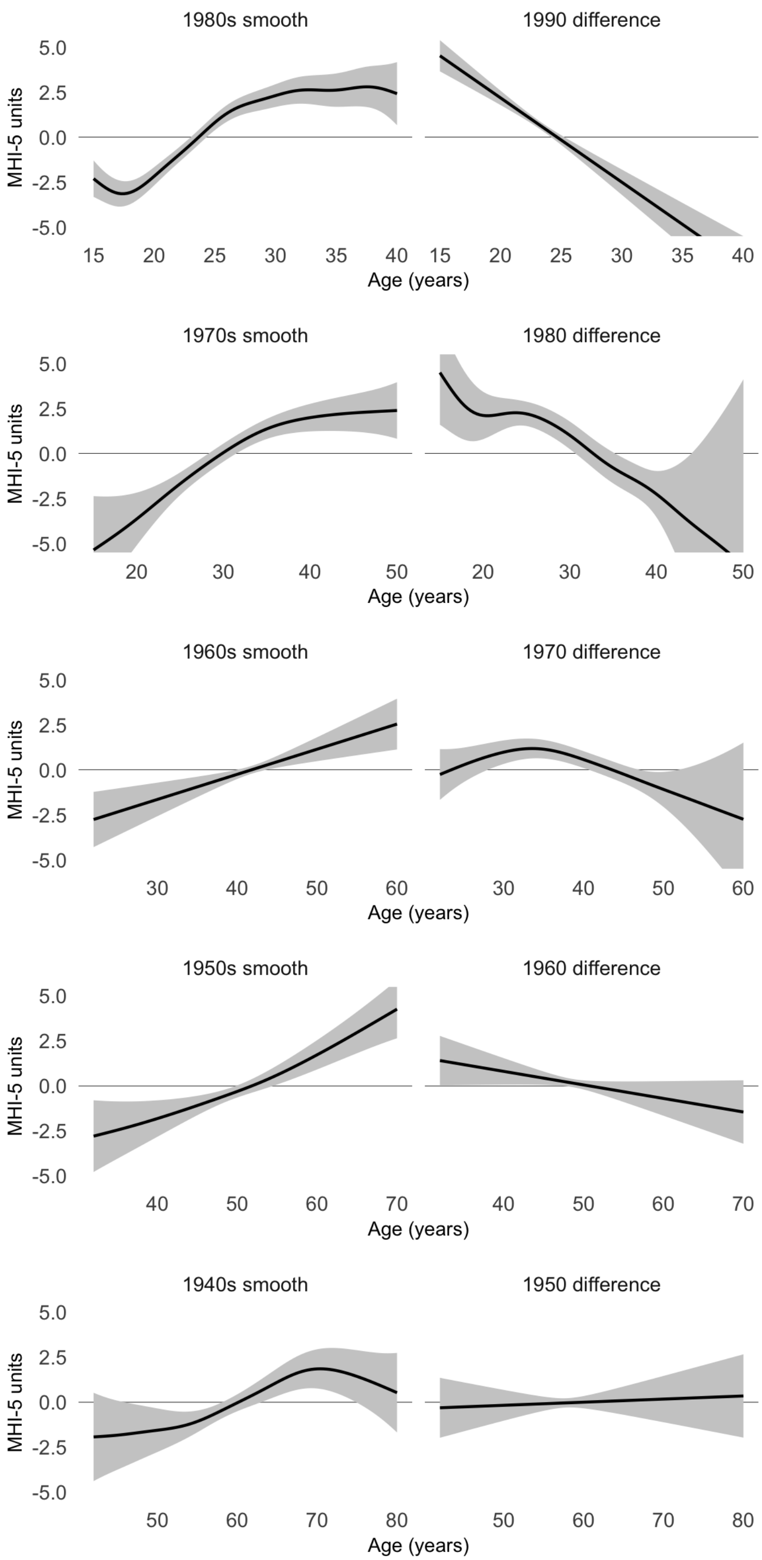

Fig. S2. Detrending period effects. Centered cohort trajectories (left) and their difference to the subsequent cohort (right), after adjustment for any linear period effect. Mental health (MHI-5 scores) were lower for later cohorts than earlier cohorts at the same age

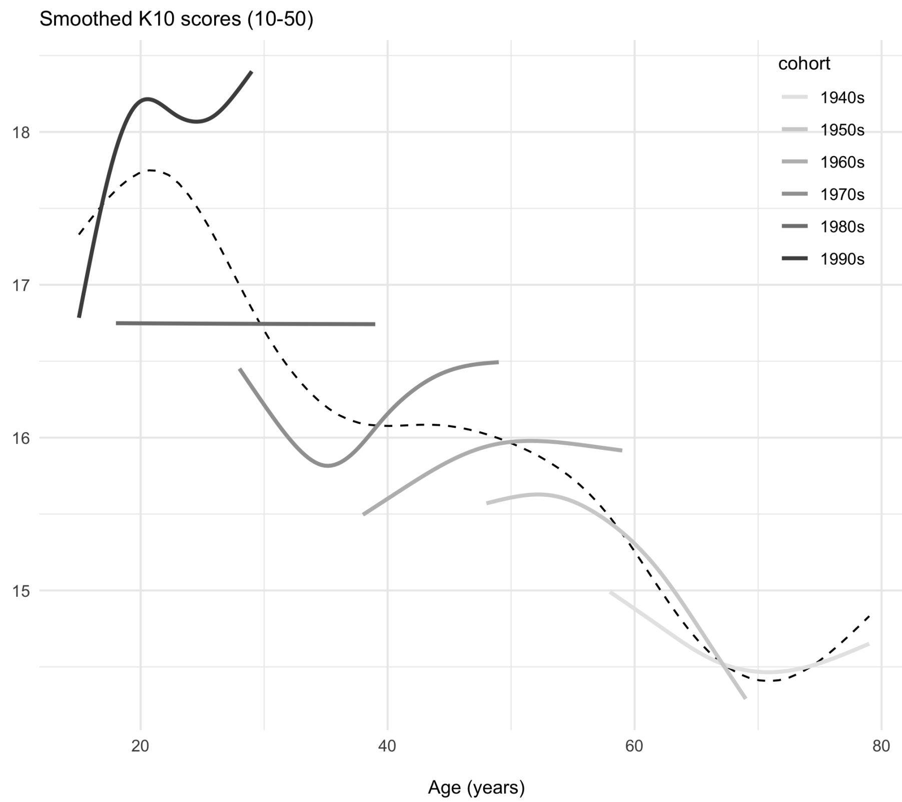

Fig. S3. Cohort trajectories in psychological distress (K10 scores). Psychological distress was higher for later cohorts than earlier cohorts at the same age.

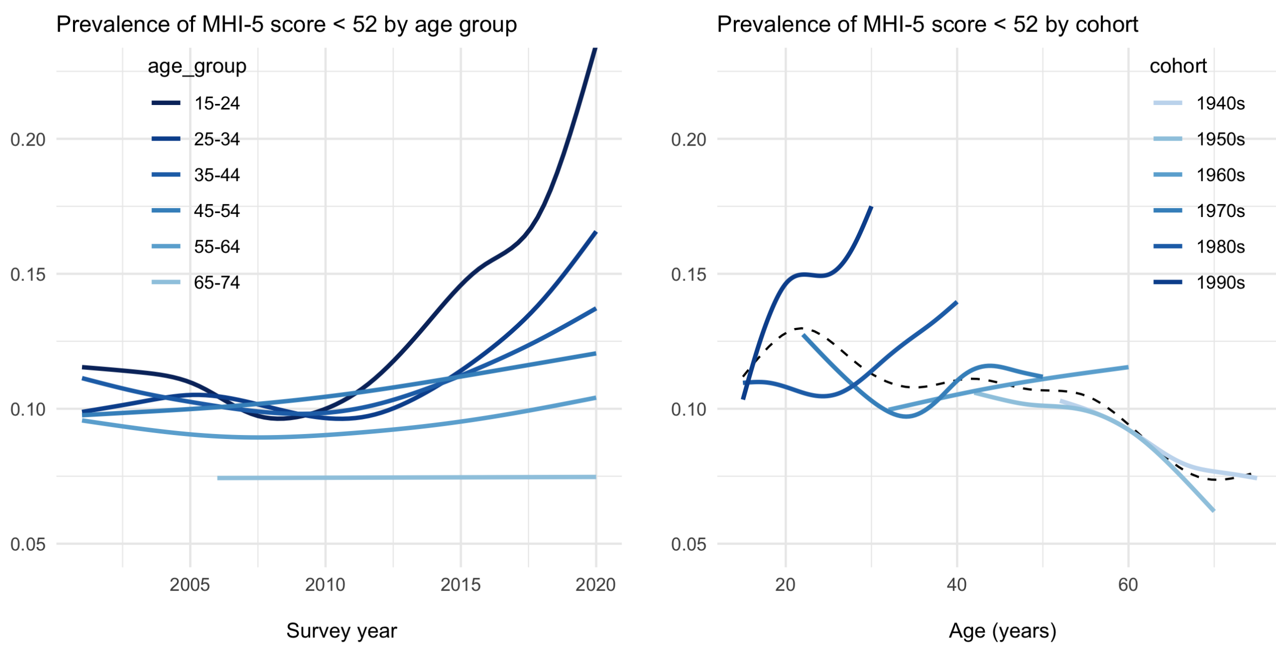

Fig. S4. Age and cohort effects on prevalence of mental illness. The prevalence of mental illness varied between age-groups and cohorts in a similar pattern as psychological distress. Prevalence was higher for younger cohorts than older cohorts at the same age.

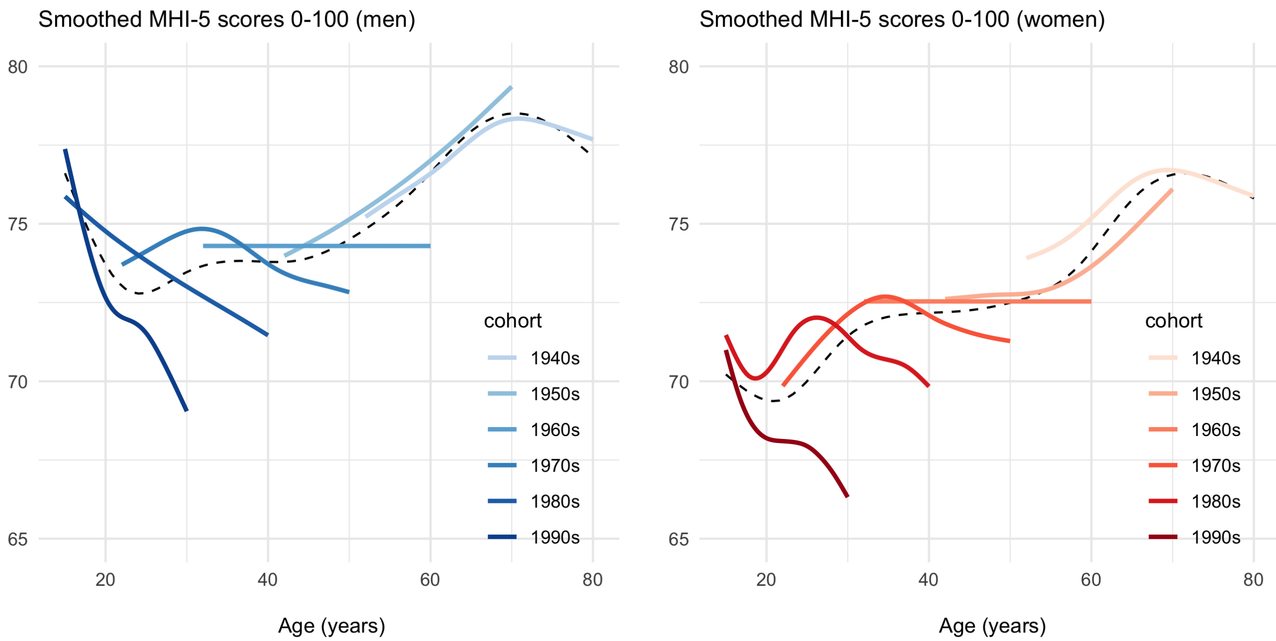

Fig. S5. Cohort trajectories in mental health for men (left panel) and women (right panel). Women have lower average MHI-5 scores than men, however men and women have similar trajectory differences between cohorts.

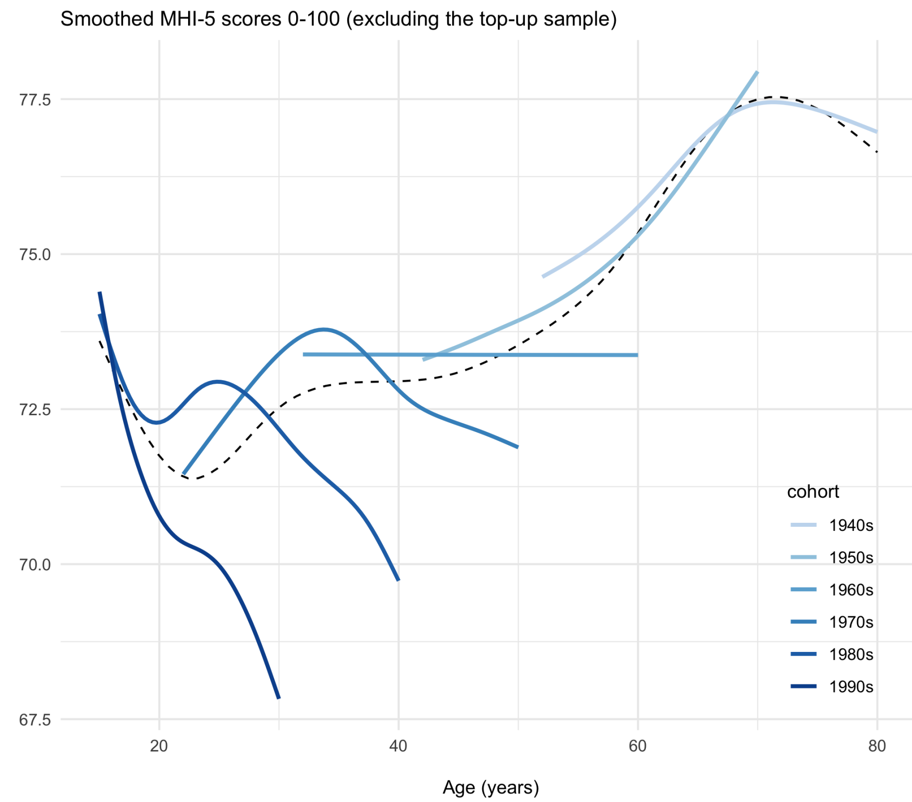

Fig. S6. Cohort trajectories in mental health excluding the top-up sample. The addition of new participants in the top-up sample in 2011 did not substantially change the cohort trajectories.

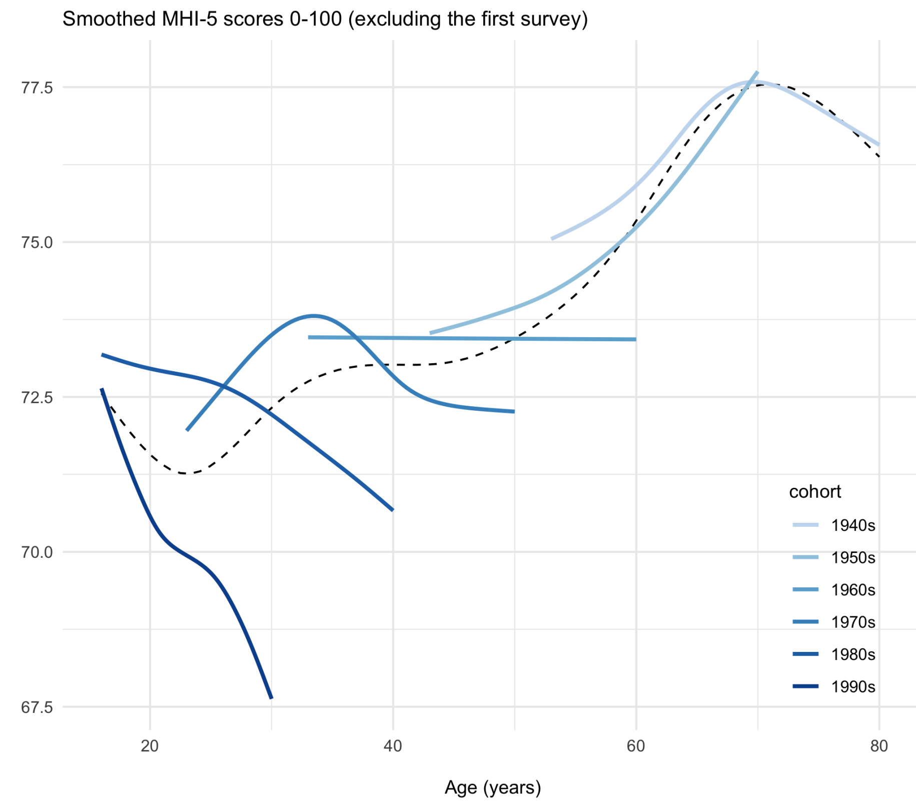

Fig. S7. Cohort trajectories in mental health excluding the first survey response. Excluding the first survey response from each person to reduce social demand effects in the results did not substantially change the cohort trajectories.

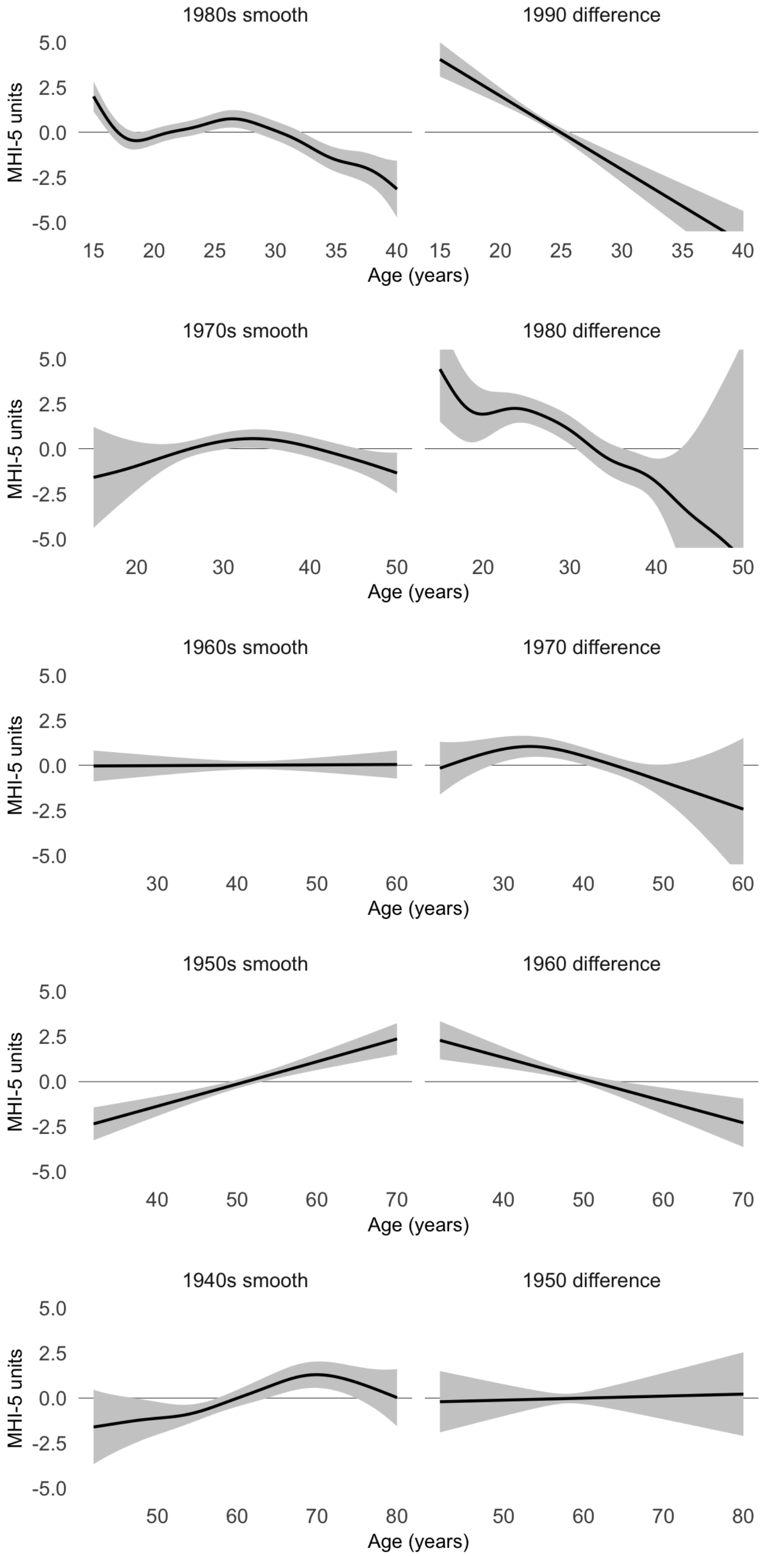

Fig. S8. Centered cohort trajectories (left) and their differences to the subsequent cohort (right) after excluding persons who are eventually lost to attrition in the panel. Removing missingness due to attrition did not substantially change the cohort differences

Table S1. Cohort differences in dependency between missingness and MHI-5 score

Cohort	OR	Difference	SE difference	z ratio	p-value
1940s	0.982	.	.	.	.
1950s	0.984	0.002	0.003	0.671	0.9851
1960s	0.993	0.009	0.002	4.272	0.0002
1970s	0.995	0.002	0.002	0.795	0.9684
1980s	0.994	0.0003	0.002	-0.167	0.9999
1990s	0.998	0.004	0.002	1.926	0.3861

SI Dataset S1 (https://github.com/datarichard/the-kids-are-alright)

The full dataset used in this report is available by application to the Australian Government Department of Social Services (DSS) https://dataverse.ada.edu.au/dataverse/DSSLongitudinalStudies. Code to generate the main analyses and Figures 1 and 2, along with software libraries and the model fit objects generated by the main analyses are available at https://github.com/datarichard/the-kids-are-alright.

References

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