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Why is greater income inequality associated with lower life satisfaction and poorer health? Evidence from the European Quality of Life Survey, 2012

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ABSTRACT
Greater income inequality is associated with lower average wellbeing. There are multiple possible explanations for this pattern. We use data from the European Quality of Life Survey 2012 (27,571 respondents from 28 countries) to evaluate the contributions of different causal pathways to associations between national income inequality and wellbeing. In unadjusted analyses, greater income inequality was associated with lower life satisfaction and poorer self-rated health. For life satisfaction, 43% of the association was attributable to individual income effects, and 41% to worse public services (especially access to healthcare). The association between income inequality and self-rated health was mainly (68%) due to individual income effects. For life satisfaction but not self-rated health, we found some evidence of costs of inequality that fall on those with high incomes. We conclude that the negative associations between income inequality and wellbeing across European countries are substantially, but not entirely, due to individual income effects.

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1. Introduction

Across many studies, greater income inequality has been associated with lower average wellbeing, whether wellbeing is measured as depression, anxiety, health, life expectancy, trust, or a number of other outcome variables (Lous & Graafland, 2022; Verme, 2011; Wilkinson & Pickett, 2009, 2010). Pickett and Wilkinson (2015) have argued that this association meets typical epidemiological criteria for causality: It is consistent across many datasets, dose-responsive, and not obviously the result of confounding variables. However, even granting the association causal status, there are multiple pathways by which inequality could affect average wellbeing (Lynch et al., 2000; Truesdale & Jencks, 2016). Demonstrating that the association is consistent, dose-responsive, and not the result of confounds does nothing to reveal the relative importance of these different causal pathways. However, the different pathways reflect different mechanisms, and may have different implications for how best to increase wellbeing.

We can identify three principal causal pathways linking inequality to average wellbeing (Lynch et al., 2000). The first is via individual income. The relationship between income and wellbeing at the individual level is non-linear. Specifically, the wellbeing return from each unit of additional income diminishes as income increases (Backlund et al., 1996; Kahneman & Deaton, 2010; Rehnberg & Fritzell, 2016). Hence, if a euro is transferred from a person at the top of the income distribution to a person at the bottom, the wellbeing of the person at the bottom increases by a large amount, because they are on the steep portion of the curve, whilst the wellbeing of the person at the top decreases only

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by a small amount, because they are on a flatter portion of the curve. Thus, the average of the individuals' wellbeing increases, the big gain at the bottom outweighing the small loss at the top. Reducing inequality is tantamount to transferring income from people towards the top of the income distribution to people towards the bottom, and thus will increase average wellbeing. Increasing inequality does the opposite. These are known as concavity effects. Concavity effects have long been acknowledged (Gravelle, 1998; Preston, 1975; Rodgers, 1979). They are mathematically inevitable as long as there are diminishing wellbeing returns to additional income. Thus, the question is not whether the individual income pathway contributes to associations between inequality and wellbeing, but, rather, whether it is sufficient to completely explain those associations, or whether other pathways are also operative. The largest meta-analysis to date suggests, for self-rated health as the outcome measure, that the individual income pathway is not completely sufficient: Pooled across studies, there are residual associations between inequality and self-rated health after controlling for individual income (Kondo et al., 2009). However, these associations are weak, suggesting that the individual income pathway may account for most of the unadjusted associations (Truesdale & Jencks, 2016).

The second pathway linking inequality to average wellbeing is via investments in public services and amenities. In more unequal societies, there may be less political willingness or capacity to make public-good-promoting investments in, for example, environmental protections, healthcare systems, or other important public services such as culture and transportation. To the extent this pathway is important, the experienced quality of public services and amenities would statistically mediate associations between income inequality and wellbeing. This has been termed the "neomaterialist" interpretation of associations between inequality and wellbeing (Layte, 2012; Lynch et al., 2004, 2000). As the term "neomaterialist" is somewhat opaque, we henceforth refer to this pathway as the "public services" pathway, noting that the interpretation of public services here is broad, and includes environmental quality as well as more obvious public services such as healthcare and transport. There is empirical evidence that more unequal societies produce worse public services. For example, Clarkwest (2008) found that more unequal US states were slower to adopt medical innovations, whilst Boyce et al. (1999) showed that more politically unequal US states—and political and income inequality were related—had weaker environmental policies, with attendant consequences for population wellbeing. However, Layte (2012), using data from the European Quality of Life Survey 2, found no evidence that selected public services variables mediated the relationship between income inequality and mental health, leading him to reject the importance of the public services pathway for this outcome and set of countries.

A third pathway has been dubbed "psychosocial." Researchers have argued that when income gaps are wide, members of the population are more aware of status differences, which causes psychological reactions that are ultimately detrimental to health and wellbeing, such as increased competitiveness and anxiety about social position (Wilkinson & Pickett, 2018). In the psychosocial pathway, the causality of the inequality is a sense more direct than in the other two. That, in the psychosocial pathway, the inequality itself has a direct psychological impact on individuals, rather than an impact completely mediated by some other material variable, be it their personal income or their experiences of public services. Experimental evidence suggests that increasing experienced inequality in the absence of any changes in people's material situation can produce changes in motivation consistent with the psychosocial hypothesis (Wang et al., 2022). However, the importance of such psychosocial effects outside the laboratory and at population scale is not known.

Disentangling the contributions of the different pathways is possible at least in principle. The bulk of the effort in the literature has gone into investigating whether the individual income pathway alone is sufficient to explain the association between inequality and average wellbeing. Such tests are only possible with multilevel datasets where measures of individual-level income and well-being, and population-level income inequality, are all available. The results of such multilevel studies, of which there are many, are often described as mixed (see, Lynch et al., 2004 for review). In some studies, the effect of inequality remains statistically significant after control for individual income (Fiscella & Franks, 2000; Kennedy et al., 1998; Shi & Starfield, 2000), suggesting insufficiency of the individual

income mechanism, whilst in others, it is attenuated to non-significance (Bobak et al., 2000; Kahn et al., 2000; Mellor & Milyo, 2002). However, comparison of statistical significance is a poor method for judging the importance of the individual income pathway. In multilevel models, the statistical power to detect significant associations at the higher (country or state) level is determined by the number of sampling units at that level. If statistical power is high, then the inequality association could remain significantly different from zero even if sharply attenuated. On the other hand, if statistical power is marginal, the association could become non-significant even if only modestly attenuated. Several of the studies that report a significant association between income inequality and wellbeing after controlling for individual income nonetheless observe considerable attenuation compared to the unadjusted association, suggesting the individual income pathway is still important (e.g., Shi & Starfield, 2000). Thus, in the present study, our focus is on the percentage attenuation in the association between income inequality and well-being once individual income is accounted for, rather than difference of statistical significance.

Here, we examine associations between inequality and wellbeing across European countries, using data from the European Quality of Life Survey 2011–2 (henceforth EQLS). Specifically, we attempt to estimate the contributions to any total associations coming from the three different causal pathways discussed above. The strategy for performing this decomposition is the following. As preliminary steps, it is necessary to show that average wellbeing is indeed lower in more unequal countries, and that there are indeed diminishing wellbeing returns to additional income. These preliminary conditions being met, we compare the strength of the income inequality-wellbeing relationships before and after adjustment for individual income, with an appropriate non-linear specification. The degree of attenuation of the associations when individual income is adjusted for is an estimate of the contribution of the individual income pathway. We then further adjust for variables capturing experience of public services. The degree of additional attenuation with these variables added is an estimate of the importance of the public services pathway. Any residual association after adjustment may reflect direct psychosocial, plus other as yet unidentified, causal pathways.

Our analysis differs in a number of ways from that of Layte (2012) also using European Quality of Life Survey data. First, we use the more recent (third) survey wave. Second, our outcomes, self-rated health and life satisfaction, though conceptually related to the mental health measure used by Layte, are different and more typically studied in the inequality literature (see e.g., Kondo et al., 2009; Verme, 2011). Third, Layte makes no attempt to measure the importance of the individual income pathway. Fourth, importantly, we differ from Layte in the way we estimate public services effects. Whereas Layte used economic measures such as government expenditures on healthcare, we use measure of experienced difficulties accessing public services that come from within the EQLS itself. The amount of government expenditure on healthcare says nothing about how equitably or efficiently it is spent. What matters for the public services pathway is people's experiences in the realm of public services and environment, and hence our more experiential variables seem directly appropriate.

In addition to our primary objective of decomposition of the contributions of the three pathways, we carried out a number of exploratory analyses of how individual income and inequality might interact, in the context both of wellbeing, and of experience of public services.

2. Materials and methods

2.1. Dataset and pre-registration

The publicly available EQLS dataset (2011-2 wave) was obtained from the UK data archive. Although this project involved secondary use of existing data, the data pipeline and planned analyses were pre-registered at https://osf.io/4ruap.

The EQLS dataset consists of responses from 43,636 individuals from 34 European countries. Six countries (North Macedonia, Ireland, Kosovo, Montenegro, Serbia and Turkey) lack a Gini coefficient provided in the original dataset. In the main paper, we use the Gini coefficients provided, and hence

the analysis covers 28 countries. In parallel, we obtained independent Gini coefficients dating from around the time of the EQLS for all 34 countries, from the World Income Inequality Database (Gradin, 2021). We repeated the central analysis for all 34 countries using these Gini values, as reported in Supplementary Analyses, section S3. We excluded respondents with missing data for income, life satisfaction or health (in over 95% of these cases, the missing variable was income). Thus, the final dataset analysed in the main paper consisted of 27,571 respondents.

2.2. Measures

2.2.1. Life satisfaction

Life satisfaction was assessed with the item: "All things considered, how satisfied would you say you are with your life these days?" (or translation; EQLS q30). Responses were on a 10-point scale anchored with 1, very dissatisfied, and 10, very satisfied.

2.2.2. Self-rated health

Self-rated health was measured with the item "In general, would you say your health is . . . ." (q42), with a five-point response scale where 1 is very good, and 5 is very bad. We treated this scale as a continuous variable. An alternative strategy common in the analysis of self-rated health and inequality is to divide the scale into the dichotomy "very good/good" versus "fair/bad/very bad" (e.g., Kennedy et al., 1998). We also performed the main analysis with self-rated health dichotomised this way (see Supplementary Analyses section S1).

2.2.3. Income inequality

Country level income inequality is provided in the dataset as the Gini coefficient of the income distribution, 2012, multiplied by 100 (i.e. total inequality would be represented by 100, perfect equality by 0; see Supplementary Analyses section S3 for alternative Gini coefficients).

2.2.4. Individual income

Respondents self-reported monthly income. This is reported in the dataset in three ways: converted into euros at prevailing exchange rate; converted into purchasing power parity (PPP) equivalent euros; and adjusted per capita for household size. The correlations between the three income measures were >0.94. We used the PPP adjusted variable. Nineteen cases had reported monthly incomes of less than three euros. We excluded these cases as they cause negative logarithms.

2.2.5. Public services

We capture quality of public services (broadly defined) using three variables, one concerning health care (q47), one neighbourhood problems (q50), and one access to other services (q51). The health care question presented five aspects of healthcare (distance to facilities, delays getting appointments, waiting times, cost, and finding time to attend). Respondents indicated if they had major or minor problems with each of the five aspects. We used the number of "yes" responses to major or minor problems. Thus, the variable is bounded at 0 and 5, with a higher number indicating more problems (mean 1.43, standard deviation 1.52). The neighbourhood problems question asked about experience of problems in six domains related to the local neighbourhood (noise; air quality; drinking water; crime, violence or vandalism; litter; and traffic congestion). We excluded the crime, violence and vandalism items, as these are plausibly consequences of inequality that reflect individual behaviour as much as public provision of services. We coded the responses as for access to health care (mean 1.35, standard deviation 1.50). Neighbourhood problems were correlated with healthcare difficulties at $r = 0.21$ ($p < .001$) at the individual level and $r = 0.66$ ($p < .001$) at the country level. The access to services item presented five domains: postal services; banking services; public transportation; cinema, theatre or culture; and recreational or green areas. We used the number of these domains in which the respondent reported some or great difficulty accessing the service (hence bounded at 0 and 5; mean

0.89, standard deviation 1.22). The access to services variable correlated with neighbourhood problems at r = 0.04 (p < .001) at the individual level and r = 0.23 (p = .246) at the country level. The correlation between access to services and healthcare difficulties was r = 0.27 (p < .001) at the individual level and r = 0.66 (p < .001) at the country level.

For the public services variables, in our main analysis, we used the country level mean as the variable for analysis, rather than the individual respondent's score. This is because the public service hypothesis is that more unequal *countries* provide lower quality public services to their citizens. Given that the hypothesis is at the country level, the proper level of specification of the operationalization is the country. Results are very similar using individual responses.

2.2.6. Control variables

As individual control variables, we included age in years (qHH2b) and gender (qHH2a) in all models. Note that even those we refer to as "unadjusted" include these controls; unadjusted means not adjusted for individual income or public services variables.

2.3. Analysis strategy

Data were analyzed using general linear and linear mixed models in R (R Core Team, 2021), with random intercepts for country where appropriate. Continuous variables were scaled for analysis, and hence all coefficients reported for continuous variables are standardized. Models are specified in Results. The presence of diminishing returns in wellbeing relationships with income was assessed by comparing AIC between models predicting wellbeing with income, or with the log of income. Although our focus is on parameter estimation rather than statistical significance, we refer to "significance" where p < .05. Analysis code is available at https://osf.io/cg27n/. Below, we present our planned analyses first for life satisfaction as the outcome variable, then for self-rated health.

To investigate the robustness of our conclusions regarding individual income effects, we also performed an additional simulation analysis (see Supplementary Analyses, section S2). In this analysis, we first estimated the associations between log income and life satisfaction/self-rated health. We then simulated the life satisfaction and self-rated health that each individual should have been expected to have based on their income alone. We then compared the associations between the income inequality and these simulated wellbeing variables to the observed associations between income inequality and actual wellbeing.

Finally, we present additional exploratory analyses concerning interactions between income inequality and other variables, rather than decomposition of the main effects.

3. Results

3.1. Main analyses: Life satisfaction

Income inequality (Gini) was a significant negative predictor of life satisfaction (Figure 1a; β = −0.18, 95% CI −0.28 to −0.07, p = .004).

The association between income and life satisfaction showed clear evidence of diminishing returns, both overall and within individual countries (Figure 1b). We fitted mixed models with either income, or the log of income, as predictors of life satisfaction. The log model was a substantially better fit to the data (AIC 74033 for the log model, 75077 for the untransformed model; an AIC change of 2 units is generally taken as evidence for an improvement in model fit; here the difference is 1044 units).

At the country level, income inequality was positively correlated with all three public services variables, although only one of these correlations was significant (health care problems, r = 0.35, p = .067; neighbourhood problems, r = 0.41, p = .029; problems other services r = 0.05, p = .813). At the individual level, all three public services variables predicted life satisfaction (health care problems, β = −0.13, 95% CI −0.14 to −0.12, p < .001; neighborhood problems, β = −0.09, 95% CI −0.10 to −0.08, p < .001; problems accessing other services, β = −0.04, 95% CI −0.05 to −0.03, p < .001). Given the

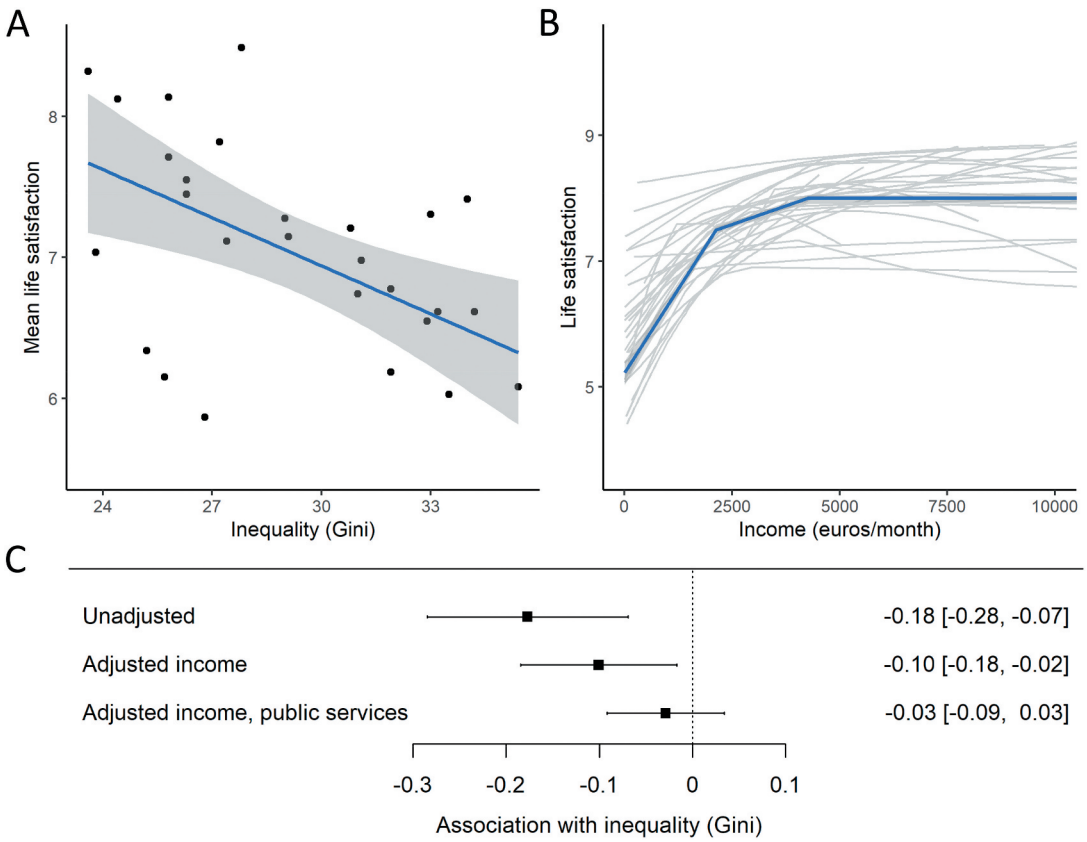

Figure 1. Results for life satisfaction. A. Mean life satisfaction against income inequality (Gini) for countries. Line represents a linear fit and shaded area 95% confidence interval. B. Relationship of income to life satisfaction at the individual level. Lines represent general additive model fits. Faint lines represent individual countries and bold line the sample overall. C. Decomposition of association between income inequality and life satisfaction. Rows show β coefficients with respectively: no adjustment other than age and gender; adjusted for logged income; and adjusted for logged income and public services.

presence of some associations between public services variables and income inequality, and strong associations between public services variables and life satisfaction, there is scope for the association between inequality and life satisfaction to be partially mediated by public services.

To decompose the association between inequality and life satisfaction into the contributions of the different causal pathways, we added first log income, and subsequently the public services variables, to the model predicting life satisfaction from income inequality. Adding log income attenuated the association by 43%, from $\beta = -0.18$ (95% CI −0.28 to −0.07, $p = .005$) to $\beta = -0.10$ (95% CI −0.18 to −0.02, $p = .027$). The addition of the three public services variables attenuated the association by a further 41% of the unadjusted association, to $\beta = -0.03$ (95% CI −0.09 to 0.03, $p = .411$). Of the three public services variables, only healthcare difficulties was a significant predictor in this model ($\beta = -0.14$, 95% CI −0.26 to −0.04, $p = .022$). Thus, the analysis suggests that the total association between inequality and life satisfaction can be decomposed roughly 43% due to individual income effects; 41% due to public service effects; and the remaining 16% possibly attributable to psychosocial effects (Figure 1c). A very similar estimate of the contribution of individual income effects to the overall association was obtained using an alternative simulation approach (Supplementary Analyses S2). Moreover, using Ginis from the World Income Inequality Database for 34 countries produced the same pattern as shown in Figure 1c, though the negative association between Gini and life satisfaction was somewhat weaker to begin with (Supplementary Analyses, section S3).

3.2. Main analyses: Self-rated health

Income inequality was negatively associated with self-rated health (Figure 2a; β = −0.09, 95% CI −0.17 to −0.01, p = .032).

The association between income and health showed evidence of diminishing returns (Figure 2b; AIC for log model 69763; untransformed model 70546). At the individual level, self-rated health was significantly predicted by health care problems (β = −0.18, 95% CI −0.19 to −0.16, p < .001) and problems accessing other services (β = −0.06, 95% CI −0.07 to −0.04, p < .001), but not neighbourhood problems (β = 0.00, 95% CI −0.01 to 0.01, p = .756).

Adjusting for logged income attenuated the association between income inequality and self-rated health by 68%, from β = −0.09 to −0.03 (95% CI −0.09 to 0.03, p = .355). Further adjustment for public services variables produced no substantial change (β = −0.03, 95% CI −0.10 to 0.03, p = .345; Figure 2c). Thus, this decomposition suggests that the association between income inequality and health is substantively (around 68%) due to individual income effects, with any remainder due to psychosocial and other processes. Dichotomising self-rated health, rather than treating it as continuous, produced almost identical conclusions (Supplementary Analyses, section S1). The alternative simulation approach also led to the same conclusions regarding the role of individual income effects (Supplementary Analyses S2). Using the World Income Inequality Database Ginis and the wider set of 34 countries, the negative association between income inequality and health was not significant to

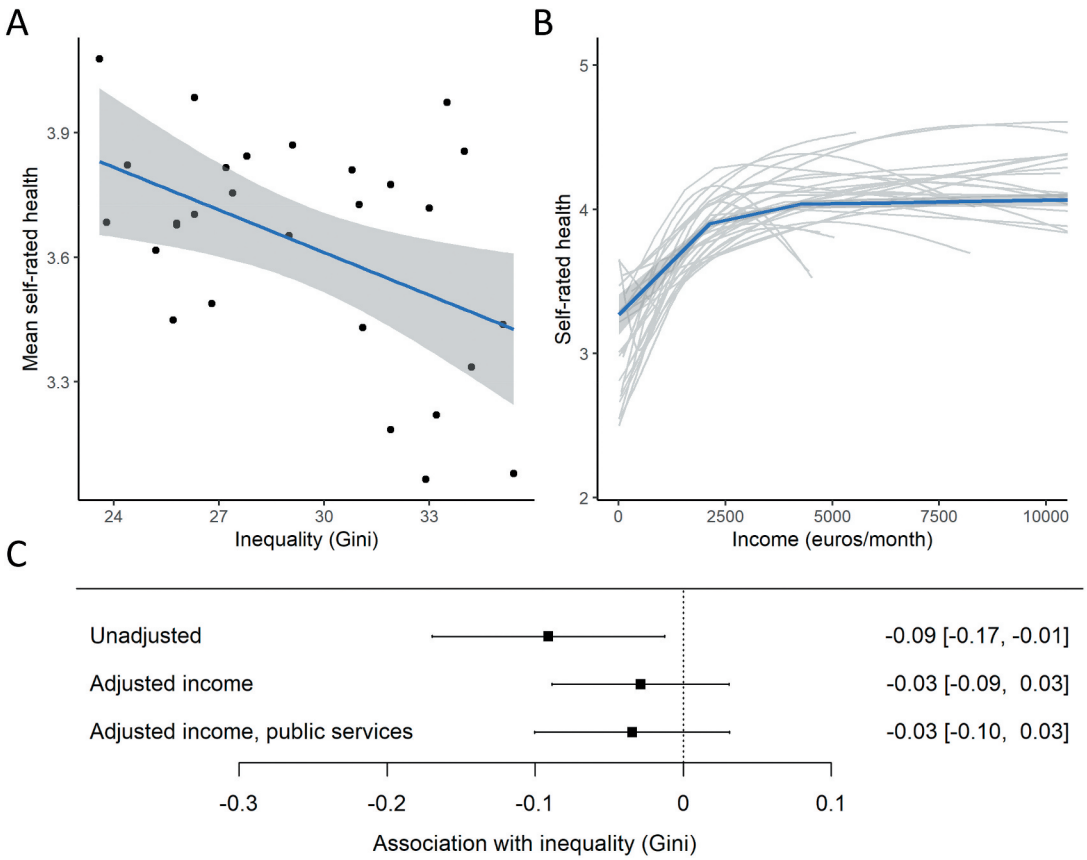

Figure 2. Results for self-rated health. A. Mean self-rated health against income inequality (Gini) for countries. Line represents a linear fit and shaded area 95% confidence interval. B. Relationship of income to self-rated health at the individual level. Lines represent general additive model fits. Faint lines represent individual countries and bold line the sample overall. C. Decomposition of association between income inequality and self-rated health. Rows show β coefficients with respectively: no adjustment other than age and gender; adjusted for logged income; and adjusted for logged income and public services.

begin with, though it remained the case that any negative trend was abolished by the addition of individual income (Supplementary Analyses S3).

3.3. Additional analyses

Income inequality was positively correlated with the public services variables, significantly so for neighbourhood problems (see above). We ran additional analyses to investigate whether the additional neighbourhood and healthcare problems fell particularly on those with low incomes in more unequal countries. To do this we fitted models with an interaction between income inequality and logged income. For neighbourhood problems, the interactive model was a better fit than an additive model (AIC 75987 vs. 76019). The interaction between income inequality and logged income was significant and positive ($\beta = 0.04$, 95% CI 0.03 to 0.05, $p < .001$). Whereas experience of neighbourhood problems decreased with increasing income in more equal countries, it increased with increasing income in more unequal ones (Figure 3a). For healthcare problems, including the interaction between income inequality and logged income only slightly improved model fit (AIC 73293 vs. 73295), and the interaction term was not significant ($\beta = 0.01$, 95% CI −0.00 to 0.03, $p = .065$).

We also investigated whether low income was particularly bad for wellbeing in more unequal countries, a claim that is frequently made (Wilkinson & Pickett, 2018). This would manifest as an interaction between income inequality and logged individual income in predicting life satisfaction or health. For life satisfaction, an interactive model fit the data better than an additive one (AIC 74022 vs. 74029). The interaction term was significant and positive ($\beta = 0.02$, 95% CI 0.01 to 0.03, $p = .002$). Although life satisfaction increased with logged income in all countries, unexpectedly, it increased more steeply with logged income in more equal countries, and less steeply with logged income in more unequal ones (Figure 3b). Although this interaction effect was statistically significant, the difference in gradient between the more and less equal countries was very modest. For self-rated health, an interactive model did not improve model fit compared to an additive one (AIC 69766 vs. 69764), and the interaction between income inequality and logged income was not significant ($\beta = 0.00$, 95% CI −0.01 to 0.01, $p = .905$).

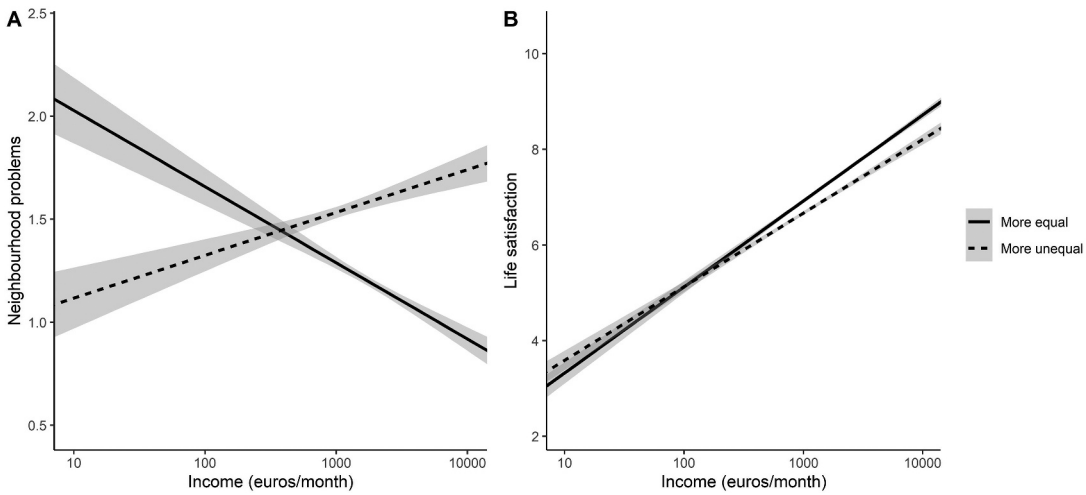

Figure 3. Interactions between income inequality and individual income. A. Relationship of logged income to experience of neighbourhood problems for more equal countries (solid line) and more unequal countries (dashed line). B. Relationship of logged income to life satisfaction for more equal countries (solid line) and more unequal countries (dashed line). Countries are split at the median Gini coefficient. Lines represent linear fits and shaded areas 95% confidence intervals.

4. Discussion

Using data from representative samples of 28 European countries, we confirmed that greater income inequality was associated with lower average life satisfaction and poorer average self-rated health. We decomposed this association into the distinct causal pathways that may contribute to it. For both outcome measures, a large part of the association was attributable to the strong concavity effects of absolute individual income on average wellbeing (43% of the total association for life satisfaction, 68% for self-rated health). For life satisfaction, a further 41% appeared to be due to residents of more unequal countries experiencing worse public services, especially, worse access to healthcare. Public services variables did not contribute to the association for self-rated health. The residual associations—about 16% of the unadjusted association for life satisfaction and 32% for self-rated health—might reflect direct psychosocial effects. However, these components were sufficiently small that we cannot claim with confidence that they differ from zero. Moreover, they could reflect other, as yet unidentified causal pathways (see, Bor et al., 2017 for discussion), and measurement error. Thus, overall, though our findings are compatible with the possibility that direct psychosocial effects of inequality exist, they also show clearly that such effects are less important than the effects mediated through individual incomes.

Although the clearest signature in our analyses was that low individual income is bad for wellbeing, we did find some exploratory evidence for the view that increasing inequality has wellbeing costs for the rich as well as the poor, which is sometimes presented as a corollary of the psychosocial interpretation. Specifically, in more unequal societies, even the people with the highest incomes experienced substantial levels of neighbourhood environmental problems (noise, congestion, air pollution, litter, etc.). Indeed, in the more unequal countries, neighbourhood problems increased rather than decreased with increasing income. We suggest that this because experiencing positive neighbourhood environments depends to a substantial degree on public goods. In a more unequal society, these may not be provided so efficiently. Increasing private income cannot mitigate the social and environmental limitations of a socio-politically unequal society (Boyce et al., 1999). Moreover, in unequal countries, those with high incomes may be particularly frustrated or fearful due to their inability to insulate themselves from broader social difficulties due to others nearby having insufficient incomes. We also found that life satisfaction increases slightly more slowly with increasing income in more unequal countries compared to more equal ones. Though this finding seems counterintuitive, it may have a simple interpretation: Life satisfaction depends on both personal resources and broader societal amenities. The weaker provision of the latter in more unequal countries impairs people's ability to convert resources into the kinds of lives that would satisfy them more as their incomes increase. This is consistent with Lous and Graafland's (2022) evidence, using data from the World Values Survey, that even those on the highest incomes see costs to life satisfaction as income inequality increases.

Our findings are consistent with key patterns previously observed in the literature. In the set of 28 countries, the association between income inequality and self-rated health was clear in the unadjusted analysis, but substantially attenuated by adjustment for income (Bobak et al., 2000; Kahn et al., 2000; Sturm & Gresenz, 2002; Truesdale & Jencks, 2016). The residual association after adjustment for individual income was in the same direction as the unadjusted association, but weak, as is typical (Kondo et al., 2009). Indeed, in the present dataset, we could not reject the hypothesis that the residual association was null at conventional significance levels. We note, however, that the degree of attenuation by adjustment for individual income may differ by the scale of sampling unit used (e.g., countries, states, census tracts; Soobader & LeClere, 1999), and differ for different demographic groups (LeClere & Soobader, 2000). The robustness of associations between income inequality and health may also differ between the USA and Europe (Lynch et al., 2004). We should also note that in the expanded set of 34 countries analysed in the supplementary analyses (section S3), the negative association between income inequality and health is not significant even in the unadjusted analysis. The expanded set of countries includes Kosovo, Macedonia and Turkey, countries that are poorer and have younger

populations than the 28 countries considered in the main paper. Thus, this finding is a reminder that the performance of Gini as a single predictor of average health, even without adjustment, will depend on the extent to which the sampling units are comparable in other ways.

Layte (2012), using a related dataset to the present one, concluded that what we are here describing as the public services pathway made no contribution to the association between income inequality and mental health. Despite measuring experience of public services in a different way that, we would argue, is more faithful to the hypothesis as stated, we reach the same conclusion for our self-rated health measure. However, for life satisfaction, public services, specifically access to healthcare, did appear to play a role. We suggest this reflects the great breadth of the life satisfaction variable as compared to health: it makes sense that public services, broadly defined, would make a more important contribution to life satisfaction than they do to health narrowly considered. To our knowledge, our findings on life satisfaction constitute the first direct evidence for the public services or "neomaterial" interpretation of associations between income inequality and wellbeing (Lynch et al., 2004, 2000).

The fact that associations between income inequality and wellbeing are in large measure mediated by other variables—individual income, and, for life satisfaction, public services—has sometimes been taken to indicate the association between inequality in wellbeing is an artefact of third variables, rather than a causal one. Indeed, the claim that the individual income pathway was important was originally described as the "artefact hypothesis" (Gravelle, 1998). However, we would counsel against this view. There must always be some intermediary mechanisms between a description of a population state, such as a measure of income inequality, and the wellbeing of individuals. The task is to characterize what those mechanisms are and establish their relative importance for particular populations. Even if the most important of those mechanisms is the concave effect of individual income, inequality would still be causal for wellbeing in the most important sense: If inequality were to increase, average wellbeing would decrease (Woodward, 2003). Indeed, the fact that, due to the diminishing returns, average wellbeing must necessarily decline as inequality increases only reinforces the view that a diminution in population average wellbeing is a regular causal consequence of increasing inequality, other things being equal.

However, the results of decomposing the contributions of the different causal pathways leads to different inferences about the likely effects of interventions. For example, policies that reduce all incomes whilst also reducing the dispersion could be wellbeing positive if the psychosocial pathway were dominant, but welfare negative if the individual income pathway were dominant. If the public services pathway were shown to be dominant, the direct goal of policy should be the provision of better public services, with the shape of the income distribution only an incidental concern. Thus, decompositions of the kind we have presented, perhaps teasing apart more subtle variants of the pathways, are required for more outcome measures, more sets of populations, and more time periods.

Our analyses have a number of limitations. First, we made no attempt to control for spatial non-independence of countries. For example, Scandinavia is typified by relatively low income inequality and relatively high life satisfaction. Counting Sweden, Denmark and Finland as separate data points may overstate the true number of historical occurrences of this coupling, since the historical development of those countries is inter-twined. Our study is not unusual amongst studies of inequality and wellbeing in this regard: Control for non-independence is usually absent or done with simple regional fixed effects where appropriate. However, recent work suggests that country-level correlations are typically inflated in the absence of effective control for non-independence; when such controls are introduced, such correlations sometimes though not always attenuate (Claessens & Atkinson, 2022). Potential non-independence is just one instance of a broader concern about cross-sectional, cross-national analyses: countries vary (or co-vary) in unmeasured ways that may actually drive observed correlations between inequality and well-being (Truesdale & Jencks, 2016). For this reason, longitudinal and panel studies, in which researchers study how wellbeing changes in response to temporal changes in inequality, provide stronger evidence of causal regularity. Second, we did not divide respondents by age category or sex, despite suggestions in the literature that associations between inequality and wellbeing may have different strengths, and be due to different causal processes, in

different demographic groups (LeClere & Soobader, 2000). Third, the variables we used to operationalize the neo-materialist or public services hypothesis do not exhaust the possible choices. This hypothesis was always stated capaciously, encompassing, non-exhaustively: "education, health services, transportation, environmental controls, availability of food, quality of housing, [and] occupational health regulations" (Lynch et al., 2000, p. 1202). The strength of our variables is that they reflect respondents' experiences in a diverse set of these domains, but we acknowledge that further proxies could be constructed, that might increase the estimated importance of the public services pathway. The hypothesis itself could also be broadened, for example, to consider the potential contribution of voluntary organizations and other community resources, which might flourish to different extents under different levels of inequality.

The current consensus in the literature on inequality and wellbeing is that the two are negatively related, but the reasons why are still—after some decades of investigation—not generally clear. We believe our analyses contribute to the unpacking of this question, paying due attention to the possibility that multiple causal processes are involved. We fully acknowledge that different causal pathways may be important for different outcome measures, different times, and different societies. We encourage other researchers to tease these apart for comparison.

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Supplementary analyses for 'Why is greater income inequality associated with lower life satisfaction and poorer health? Evidence from the European Quality of Life Survey, 2012'

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S1. Treating self-rated health as dichotomous

We dichotomized self-rated health into 'very good/good' versus 'fair/bad/very bad'. We repeated the central analyses for self-rated health using logistic regression on this dichotomous outcome. In an adjusted analysis, increasing income inequality was associated with reduced odds of very good/good health (OR = 0.81, 95% CI 0.68 to 0.96, p = 0.013). Adding individual income to the model attenuated this association by 70% (OR = 0.94, 95% CI 0.82 to 1.07, p = 0.336). Further adjusting for public services did not lead to any further change (OR = 0.94, 95% CI 0.80 to 1.07, p = 0.318). Thus, results and inferences using self-rated health dichotomized were very similar as for the continuous analysis reported in the main paper (figure S1).

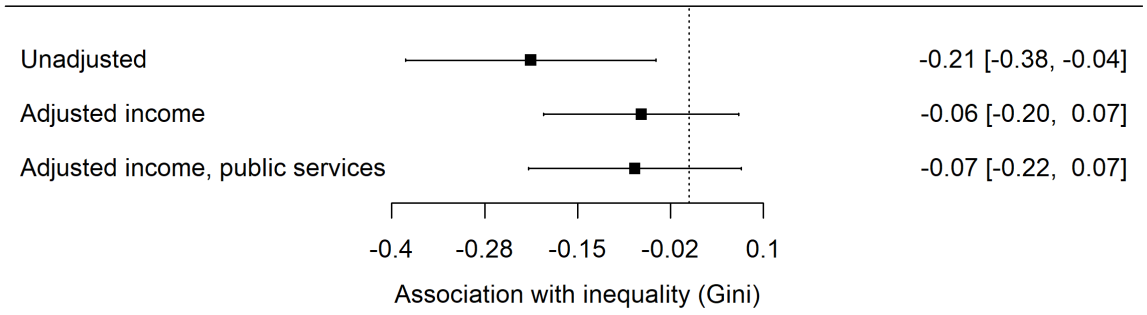

Figure S1. Decomposition of association between income inequality and self-rated health treated dichotomously. Rows show log odds ratios with respectively: no adjustment other than age and gender; adjusted for logged income; and adjusted for logged income and public services.

S2. Investigating individual income effects through simulation

To explore the robustness of our conclusions concerning the contribution of the individual income pathway, we carried out an additional simulation analysis. The simulations used a different statistical approach to explore what association between income inequality and well-being should be expected on the basis of individual income concavity effects alone, and the degree to which, for each outcome, there was evidence of any association once these were accounted for. Here, we report the results in turn for life satisfaction and self-rated health.

Life satisfaction

We first fitted a regression model predicting life satisfaction from log income in the whole dataset, ignoring income inequality and country. Using this model, we simulated life satisfaction values for

every individual given their personal incomes. We then fitted a model with income inequality (Gini) as a predictor of simulated life satisfaction. The predictive power of Gini in this model is a direct estimate of the expected magnitude of individual income concavity effects. Across ten runs of the simulation, Gini was always associated negatively with simulated life satisfaction (mean parameter estimates: β = -0.08, 95% CI -0.12 to -0.04, all ps < 0.002). This corresponds almost perfectly to the attenuation of the association between Gini and observed life satisfaction when individual income is added to the model using the method in the main paper (see figure 1 of main paper). Thus, on the basis of individual income alone, we generated a country-level association between Gini and simulated life satisfaction, though it was shallower than the association actually observed (figure S2A).

Next, we computed, for each individual, the difference between the life satisfaction simulated on the basis of their income, and their observed life satisfaction. This is the deviation of individuals' life satisfactions from those that would be expected given their income alone. We regressed this deviation on the Gini coefficient. Across ten runs of the simulation, there was a weak association (mean parameter estimates: β = -0.07, 95% CI -0.13 to -0.01, ps 0.018 to 0.065). This is a direct estimate of the association between income inequality and life satisfaction that is *not* due to individual income. It is of similar magnitude to the association obtained in the main paper by controlling statistically for individual income.

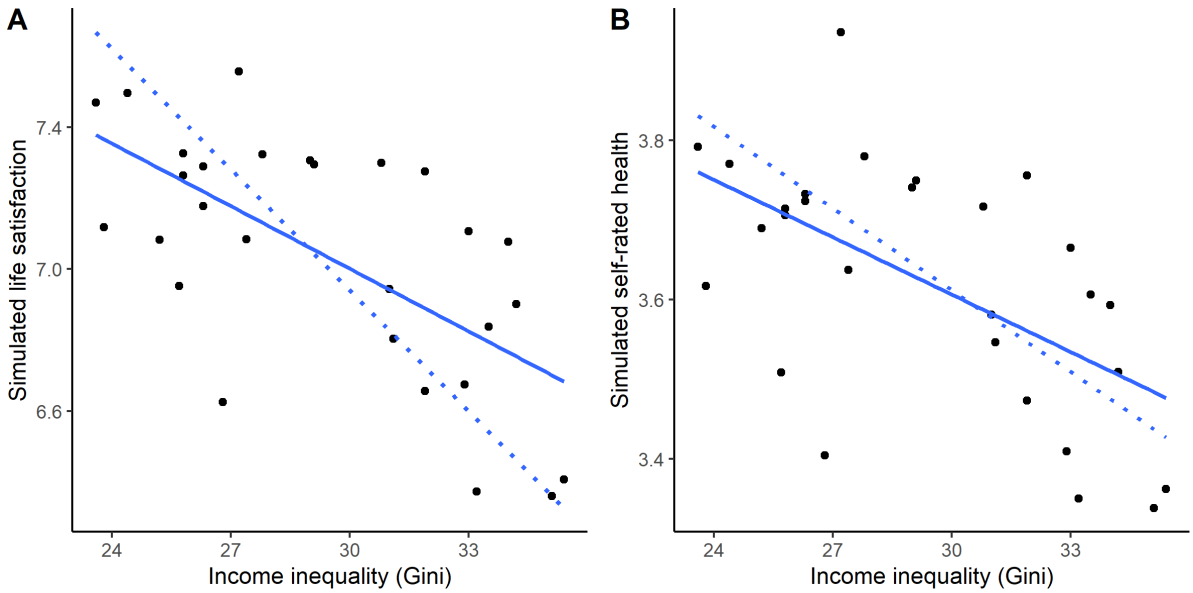

Figure S2. Associations between income inequality and average wellbeing values simulated on the basis of individual income alone. A. Life satisfaction; B. Self-rated health. In each panel, the points are simulated country averages, the solid line represents the association between Gini and the simulated wellbeing data, and the dotted line represents the association between Gini and the actual wellbeing values found in the dataset.

Self-rated health

Using the same method as described for life satisfaction, above, we found that self-rated health simulated on the basis of individual income alone was negatively associated with income inequality (ten runs, mean parameter estimates: β = -0.09, 95% CI -0.14 to -0.05, all ps < 0.001). We then calculated the difference between individuals' income-predicted health, and their observed health ratings. This was not significantly associated with income inequality (ten runs, mean parameter estimates: β = -0.00, 95% CI -0.05 to -0.04, all ps > 0.10). The association between income inequality and self-rated health observed in the data was scarcely steeper than the association between income inequality and self-rated health simulated on the basis of income alone (figure 2B). Thus, this analysis reinforces the conclusion in the main paper that the association between income inequality and self-rated health is substantively explained by individual income concavity effects.

S3. Alternative Gini coefficients from the World Income Inequality database

As six countries lack a provided Gini coefficient in the EQLS data, we independently obtained Gini coefficients for all 34 countries from the World Income Inequality database (WIID; Gradin, 2021). Specifically, we used the variable 'gini_std' from the companion version of the dataset. We used the year 2012 where available, and where not, the closest year (maximum discrepancy 2 years). For the 28 countries with both EQLS and WIID Ginis, the correlation between the two was 0.90 (p < 0.001).

Figure S3 shows the results of the central analysis for life satisfaction using the WIID Ginis. The patterns were extremely similar to the analyses reported in the main paper, but all associations were slightly weaker: a significant negative association between Gini and life satisfaction in the unadjusted model (β = -0.15, vs. -0.18 in the main paper); substantial attenuation by the inclusion of individual logged income (to β = -0.07, vs. -0.10); and effectively total attenuation by the further inclusion of public services variables (to β = 0.02, vs. -0.03).

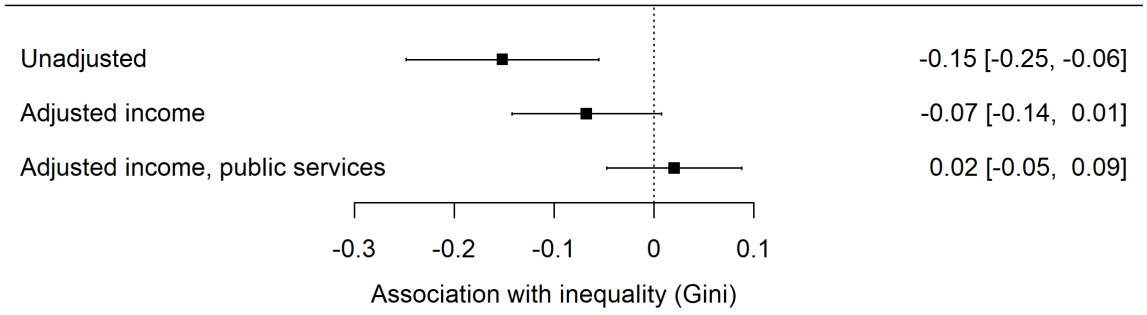

Figure S3. Repeat of figure 1C of the main paper, using the WIID Ginis, and hence 34 countries, in place of the EQLS Ginis and hence 28 countries as reported in the main paper. The outcome variable is life satisfaction.

For self-rated health, results using the WIID Ginis were more discrepant from those reported in the main paper than for life satisfaction (figure S4). Specifically, the negative association between Gini and average health was non-significant and very weak even in the unadjusted model (β = -0.03, vs. -0.09 in the main paper). Adjusting for income reduced any trend towards a negative relationship.

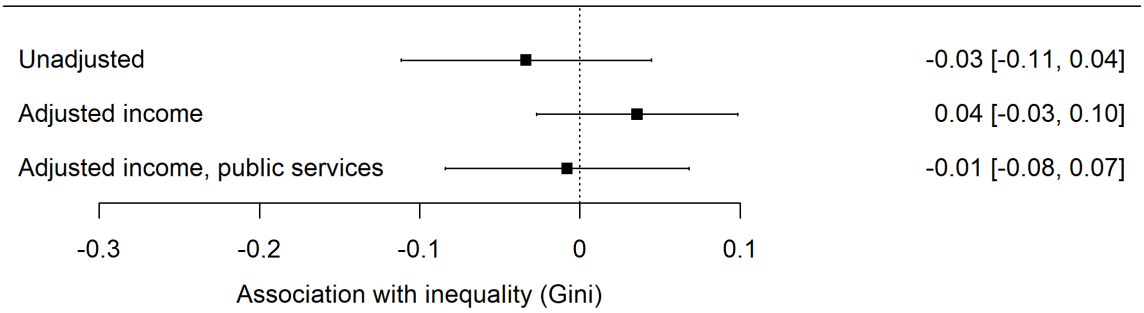

Figure S4. Repeat of figure 2C of the main paper, using the WIID Ginis, and hence 34 countries, in place of the EQLS Ginis and hence 28 countries as reported in the main paper. The outcome variable is self-rated health.

Thus, nothing in the analysis using the WIID Ginis and the expanded set of countries contradicts the claim of the main paper, that where there are negative associations between income inequality and wellbeing, they are substantially attenuated by adjustment for (the curvilinear effects of) individual income, and, for the case of life satisfaction, further attenuated by adjustment for public services. However, it also shows that the presence or strength of negative associations between income inequality and wellbeing even in an unadjusted analysis is rather variable depending on the countries being compared.

Adding in the six extra countries substantially increased the heterogeneity of the country set, because the six countries with missing EQLS Ginis included Kosovo, Turkey and Macedonia. These countries are both poorer overall, and have younger populations, than the relatively homogeneous set of 28 countries examined in the main paper. (Although our 'unadjusted' analysis controlled for age, the association between age and health is very strong, and our linear control may not have completely removed age effects.) It is to be expected that Gini will perform best as a predictor in countries that are otherwise as similar as possible, and hence it is comprehensible that expanding the country set would reduce its predictive power.

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