Within family influences on compliance with social distancing measures during COVID-19 lockdowns in the UK

Authors: Ozan Aksoy (1)

Affiliation: (1) Centre for Quantitative Social Science, UCL Social Research Institute, University College London, 55-59 Gordon Square WCH1 0NU, London United Kingdom, email: ozan.aksoy@ucl.ac.uk

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Abstract:

Compliance with public health measures of adolescents who are often unfairly portrayed as spreaders of COVID-19 is essential for containing diseases. But does adolescents' compliance develop independently from their parents? Using nationally representative longitudinal data and cross-lagged Structural Equation Panel Models I study compliance with social distancing measures of 6,752 triplets that comprise the adolescent child (age 19), their mother, and father during two national lockdowns in the UK. Results show that adolescents have the lowest and their mothers have the highest levels of compliance, and compliance generally drops over time. Moreover, mothers, and when the child lives with their parents, fathers have significant influence on their adolescent child's compliance. The child also influences their fathers' compliance. The parental influence on adolescents' compliance documented here suggests that family dynamics play a role in compliance with social distancing guidelines, which may be useful for informing future health policy.

Main

Young adults' and adolescents' compliance with public health measures is essential for containing the spread of diseases such as that caused by 2019 coronavirus (COVID-19).[1 2] Adolescents can be infectious while remaining asymptomatic or only showing mild symptoms.[3] This group also has a strong need for social connection and hence can be highly effective in spreading the disease.[4] Unfortunately, adolescents and young adults are also identified as having relatively low levels of compliance with public health measures.[5 6] Campaigns during the COVID-19 pandemic have thus explicitly targeted this group (e.g. here and here), and proposals have been made to utilise social media "influencers" with large adolescent following.[4]

A key factor that shapes compliance is social influence.[2 4 7 8] Especially perceived behaviour of those in adolescents' close circles is shown to influence adolescents' compliance with public health restrictions.[8] Social influence in general is thought to amplify both risky as well as beneficial behaviours, particularly among adolescents.[4 7]

Social influence on compliance with public health restrictions can be understood from a social norm framework.[9] When public health authorities announce a certain restriction, they prescribe an *injunctive norm* (i.e. what is ought to be done collectively).[10] Injunctive norms are different from, and can even be in conflict with, *descriptive* norms (i.e. what is believed to be practiced in reality by most people).[10 11] Injunctive norms will be stronger if they are in sync with descriptive norms. Indeed, research has shown that perceptions of others' compliance with and approval of restrictions are associated with respondents' own compliance[8 12 13 14] and that compliance with restrictions has been stronger in communities with high pre-pandemic levels of social capital and cohesion.[15] Conversely, people who accept the injunctive self-isolation norms but do not perceive widespread compliance experience a strong loss of trust in others and reduced compliance.[16 17] Interestingly, while perceptions of others' compliance have a positive correlation with trust in others, one's own agreement with social distancing norms has a negative association with trust.[16]

The literature of norm compliance during the pandemic is, however, scarce as to perhaps one of the strongest forms of social influence, namely parental influence. In existing research, a generic inner circle's norm compliance is studied without a specific reference to parents.[8 12 17 18] Social science research has shown that parents are highly influential in shaping adolescents' values, attitudes, beliefs, and indeed behaviour.[19 20 21 22] Socialisation theory explains this parental influence via a myriad of channels. Parents can shape their children's values, behaviour, and norms through modelling whereby children observe their parents' behaviour and expressed attitudes; through formal training whereby parents directly instruct expected behaviours; and through conditioning with rewards and punishment shaping children's behaviour.[23] Interestingly, past research has shown a particularly strong influence of mothers and a relatively weak influence of fathers on adolescents' values and behaviours.[19 22] This stronger influence of mothers relative to fathers is often explained by the tendency that mothers interact more frequently with offspring than fathers do,[19] and that mothers are often more involved in their children's activities outside the home, such as educational and social events.[22]

Additionally, while transmission of values, beliefs, norms, and behaviour predominantly occur from parents to child,[24] when the child reaches late adolescence, parent-child relationship dynamics change.[25] During late adolescence, while parental power decrease, conflict with parents and the influence of peers–both of which tend to increase from early to mid-adolescence—decrease, too.[26 27] Overall, parental influence tends to rebound and stabilise from age 16 to 19. This means that parental influence persists during and even beyond late adolescence, and that as parent-child relationships become more egalitarian adolescents also start exerting some influence on their parents, albeit a smaller one than parents do on their children.[25 26 27]

Given the above literature, one expects a strong influence of parents, particularly mothers on adolescents' compliance with pandemic restrictions, and some, perhaps a weaker influence of adolescents on their parents' compliance. To my knowledge, however, there is no research on within family influence on compliance during the COVID-19 pandemic. Moreover, the pandemic presents a novel research setup which helps address some other gaps in our knowledge regarding within family transmission of norms and values. Authorities raised a very strong and novel injunctive public health norm during the pandemic. The extent to which compliance with this norm is transmitted across generations will shed light into the transmission process. For example, while past research studied transmission of values that have deep roots in society, such as religious beliefs,[20] gender and work norms,[23 28] and other value orientations such as hedonism, achievement, self-direction;[29 30] it is not known yet whether a similar transmission process occurs for a specific and novel norm, such as compliance with a particular set of public health measures.

In this article, I study how parents impact their adolescent child, and the adolescent child their parents in complying with social distancing measures. In addition, I investigate how living arrangements such as whether the child co-resides with their parents during the lockdowns and relationship quality in the family moderate within family transmission of compliance. Relationship quality is found to be a key moderator of interpersonal influence; hence it is important to study how much within-family transmission processes vary by the quality of parent-child relationship.[23 25] In addition, whether the child co-resides with parents may be another important moderator of within-family transmission of compliance. Firstly, physical proximity is directly related to intergenerational cohesiveness.[31] Secondly, sharing the same living space may facilitate socialisation, for example observing parents' behaviour for modelling, and monitoring and reinforcing children's behaviour are easier when children and parents live together.

I address the research questions using the longitudinal UCL COVID-19 survey which collects compliance data during the two national lockdowns enacted in the UK, one in May 2020, another in February/March 2021. The UCL COVID-19 survey is implemented as an extension of existing cohort studies, and most relevantly of the Millennium Cohort Study (MCS).[32 33] Data have been collected from the main MCS respondent who were at the age of 19 during the two national lockdowns. In addition, the parents of the main respondent have also been asked to respond to the survey independently. Using the pre-pandemic MCS sweeps I reconstructed family triplets that comprise the child, the mother, and the father (see below the methods section).

Next to addressing the knowledge gaps discussed above, the dataset and the models I use also ameliorate several methodological shortcomings in the literature of social influence and compliance. Firstly, in almost all existing studies, the extent of others' compliance is based on self-reported measures from the respondent. The link between compliance and expectations of others' compliance could thus simply reflect a projection of one's own compliance to others.[8 34] In the dataset I use, compliance is measured independently from each member of the child, mother, and father triplet. Secondly, most studies on compliance rely on cross-sectional or prospective data.[8 12 17 18] This shortcoming is particularly important in understanding social influence on compliance, for a link between compliance and compliance of others could reflect similar people self-selecting into similar environments (e.g. those who are already complying with the norm are more likely to be friends) rather than genuine social influence (e.g. one friend influencing another to comply).[34] Those that utilise longitudinal data have explored a plethora of predictors of compliance but did not explore the association between social influence and compliance.[1] The longitudinal nature of the data I use allows to decompose the causal chain (i.e. parental influence on child versus child's influence on parents). Moreover, having repeated measures on the child, the mother, and the father allows to control for ultimately *all* observed and unobserved time-invariant household level factors (e.g. socioeconomic background, geographic region, ethnic composition of the household etc.) through the use of so-called household fixed effects. This feature of the data and the modelling strategy gives strong leverage to address omitted variable bias.[35]

Next to addressing knowledge gaps in the literature, a focus on within family dynamics of compliance with health measures may be beneficial from a public health policy perspective. Media campaigns targeting young adults (e.g. here and here) as well as policy research[5] during the COVID-19 pandemic portray this group as distinct and sometimes deviant. Adolescents are often stigmatised unfairly as "spreaders of the virus".[36] Identifying parental influence on adolescents' compliance may firstly redistribute some of the responsibility across all generations.

Secondly, recognising within family influences may help develop better public health campaigns. The data I use here are based on recent but past episodes of national lockdowns. As of writing this article, there is no public health restrictions in the UK. However, how the COVID-19 pandemic will evolve is still unclear. With the emergence of new virus variants new restrictions may be needed. Even after the COVID-19 pandemic is safely behind us, there will be other epidemics. The results of this study imply that public health campaigns that not only target adolescents and young adults, but also their parents, and that acknowledge within family dynamics in compliance with public health measures may have better chances of succeeding than those that ignore such dynamics.

Results

Descriptive results

I first estimate through Full Information Maximum Likelihood (FIML) the means, variances, and covariances of compliance with social distancing measures during the two national lockdowns, namely that in May 2020 and in February-March 2020. These descriptives are given in Table 1. Figure 1 shows average compliance of the child, the mother, and the father at two time points, again estimated with FIML. All *P*-values reported below are based on two-sided tests.

Among both children [$\chi^2(1) = 653.79$, $P < 0.001$] and the mothers [$\chi^2(1) = 8.60$, $P = 0.003$] compliance has been significantly lower in the subsequent lockdown than the first (Figure 1). The drop in compliance of children has been stronger than that of the mothers [$\chi^2(1) = 343.12$, $P < 0.001$]. The fathers' mean compliance, however, does not change significantly over time [$\chi^2(1) = 0.63$, $P = 0.426$]. Overall, mothers have the highest compliance levels, children the lowest, fathers in between but closer to mothers' than to children's; the differences in compliance between mothers, fathers, and children in the two time points are statistically significant [$\chi^2(4) = 1292.96$, $P < 0.001$]. However, recall that the maximum compliance score is 10, and all means including those for children are close to the maximum. Table 1 shows that all correlations, but between fathers' compliance in the first lockdown and their child's compliance are large and statistically significant.

Within family influence

Figure 2 shows the two models fitted to the data. In both versions, in each timepoint the mother's and the father's compliance affect the child's compliance. These predicted effects from parents to children (i.e. b_{mc1}, b_{mc2}, b_{fc1}, b_{fc2}) are based on previous research in socialisation and developmental psychology which shows that parents dominate the transmission process in that parents transmit values to children whereas adolescents have limited effects on their parents.[24 25] The paths from a parent to child in the two timepoints are estimated freely. An alternative version would constrain these paths to be the same (i.e. $b_{mc1} = b_{mc2}$, $b_{fc1} = b_{fc2}$), which would impose the extent of parent-child transmission to be the same in the two time points. Due to the novelty of the public health restrictions during the pandemic, however, one may conjecture a stronger influence in the first lockdown than the second. I will test this conjecture below. In addition, as mentioned above research has also shown that adolescence children also exert some limited influence on their parents, smaller one than parents do on their children.[25] This possibility is captured by the paths from the child's compliance in timepoint 1 to parents' compliance in timepoint 2 (b_{cml} and b_{cfl}). Note that the child's possible influence on their parents can also be captured as contemporaneous paths (i.e. reciprocal paths for $b_{mc.}$ and $b_{fc.}$). However, adding those reciprocal paths is complicated methodologically, for they would make the model non-recursive, and without further constraints on the paths the model would be unidentified.[37] Given the theoretical expectation that parents dominate the influence process and these methodological reasons, I opted for the specifications in Figure 2. Nevertheless, I will test below contemporaneous paths from the child to their parents, with additional cross-time equality constraints on parameters to identify the model.

The models also include lagged direct effects from parents to child (b_{mcl} and b_{fcl}) and an individual's compliance in timepoint 1 affects their own compliance in timepoint 2. These latter autoregressions capture within person "stability" in compliance.[38]

The version in Figure 2b includes household fixed effects. Those household fixed effects, as in conventional multilevel regression framework, can be thought of as dummy variables—one for each household. They capture the effect of all observed and *unobserved* time invariant factors defined at the household level (e.g. family socioeconomic background, ethnic and educational composition of the household, location of residence etc.). In the Structural Equation Modelling Framework, these fixed effects can be included in models as a latent variable. The indicators of this latent fixed effect variable are all endogenous variables whereby the paths from the latent variable to the endogenous variables are constrained to 1.[39] If we expanded the model with further exogenous time-varying or time-invariant explanatory variables (which I will do in the additional analyses subsection below), those variables will be allowed to freely correlate with the latent variable FE (i.e. household fixed effects, see Supplementary Methods section 1 and Supplementary Figure 1 for an illustration). In the model in Figure 2b, thus, every time invariant variable defined at the household level is controlled for. This provides strong leverage in addressing omitted variable bias, and hence make a causal interpretation more credible.[32] The interpretation of the paths in Model B, however, is different than those in Model A. In Model B, the paths are about the effect of *within* household change in compliance on *within* household change in compliance.

Table 2 shows the estimation results for Model A and B in Figure 2 and selected fit measures. Figure 3 plots the path coefficients from the same set of results. Fit measures show that both Model A and Model B fit data reasonably well. A likelihood ratio test [LR $\chi^2(1) = 5.60$, $P = 0.018$] and the AIC suggest that Model B has a slightly better fit than Model A, while the BIC suggests that Model A has better fit than Model B.

Estimated path coefficients show that the mother's compliance affects their child's, particularly during the first lockdown. A unit increase in the mother's compliance score in timepoint 1 is associated with, depending on model specification 0.3 ($b = 0.29$, $P < 0.001$ in Model A) to 0.2 ($b = 0.17$, $P = 0.010$ in Model B) points increase in the child's compliance in timepoint 1. Note that, an effect of 0.17 in Model B is a *within* household effect, net of all time invariant observed and unobserved household-level factors. The mother to child effect is smaller in timepoint 2: 0.13 in Model A and 0.06 in Model B. A formal test of the differences between the paths b_{mc1} and b_{mc2} is statistically significant in Model A [Wald $\chi^2(1) = 5.86$, $P = 0.016$] and insignificant at the 0.05 level in Model B [Wald $\chi^2(1) = 2.81$, $P = 0.094$]. This suggests some reduction in maternal influence in the subsequent lockdown than the first.

The path coefficient from the father to the child, however, is statistically insignificant in both specifications for both timepoints [respectively in Model A and B, b = 0.073, $P = 0.177$ and b = -0.002, $P = 0.973$ (timepoint 1); b = 0.045, $P = 0.494$ and b = -0.026, $P = 0.707$ (timepoint 2)]. But the father's compliance is correlated significantly with the mother's compliance [e.g., in timepoint 2, covariance between the mother's and father's compliance is estimated as .278, $P < 0.001$ [Model A] and as .141, $P =.027$ (Model B)], and hence indirectly with the child's compliance too particularly in timepoint 2 (correlation between father's and child's compliance in timepoint 2 is 0.144, $P < 0.001$).

The lagged paths from the mother (b_{mcl}) and the father (b_{fcl}) in timepoint 1 to child in timepoint 2 are statistically insignificant. Again, this does not imply that compliance of the parents in timepoint 1 has no effect on the compliance of the child in timepoint 2. In fact, the *indirect* effect of mother's compliance in timepoint 1 on their child's in timepoint 2 through their own compliance in timepoint 2 and the child's compliance in timepoint 1 are significant (indirect effect = 0.18, $P < 0.001$ in 2a; indirect effect = 0.08, $P = 0.025$ in Figure 2b).

The path from the child to the mother is significant too in Model A (b = 0.077, $P = 0.002$) but attenuates to null once household fixed effects are controlled for in Model B (b = 0.01, $P = 0.769$). On the other hand, the path from the child to the father is statistically significant in both specifications (b = 0.187, $P < 0.001$ in Model A, b = 0.102, $P = 0.035$ in Model B). This means that adolescents exert some influence on their parents, particularly on their fathers, while they are influenced mainly by their mothers.

Not surprisingly, the path from one's own compliance at timepoint 1 to that at timepoint 2 is generally large and statistically significant [the smallest of those autoregression paths is from mother (t = 1) to mother (t = 2) which is estimated as .240, P < .001 in Model B, and the largest is from father (t = 1) to father (t = 2) estimated as .51, $P < .001$ in Model A].

Additional results

In Model A and Model B, parental influence on the child is contemporaneous while there is no contemporaneous path from child to parents, in keeping with the finding in the literature that parents dominate the influence process. It is, however, possible to add contemporaneous paths from the child to both the mother and the father (i.e. adding paths reciprocal to $b_{mc.}$ and $b_{fc.}$ in Figure 1), though to identify the model with those reciprocal effects one would need to constrain the set of path coefficients from parents to child and that from child to parents in the two time points to be equal (i.e. $b_{mc1} = b_{mc2}$, $b_{fc1} = b_{fc2}$, $b_{cm1} = b_{cm2}$, $b_{cf1} = b_{cf2}$). However, those contemporaneous paths from the child to the parents are statistically insignificant at the 0.05 level [LR $\chi^2(2) = 5.93$, $P = 0.052$ in A and LR $\chi^2(2) = 3.45$, $P = 0.179$ in B]. Hence, there is not enough evidence in the data for a contemporaneous effect of child on their parents, given the rest of the model.

I then test how living arrangements moderate the paths in Figure 2, particularly whether the child lived with parents during the lockdowns. To do so, I fit a multiple group version of Model A in Figure 2 (Model B failed to converge with multiple groups) whereby the parameters are allowed to differ for families whose children were at home during the lockdowns versus those whose children lived away from their parents. Indeed, the parameters differ significantly across these two groups [LR $\chi^2(25) = 361.04$, $P < 0.001$]. Most notable differences are that for children who stayed away from their parents, there was no significant parental influence at timepoint 2 [Wald test of all four paths from parent's compliance to child's compliance in timepoint 2 is $\chi^2(4) = 1.41$, $P = 0.842$] and a weak maternal and insignificant paternal influence at timepoint 1 (paths respectively from mother's and father's compliance to child's compliance at timepoint 1 are: b = 0.19, $P = 0.02$ and b = 0.11, $P = 0.244$). Whereas for children who lived with their parents, parental influence was significant in both timepoint 2 [Wald $\chi^2(4) = 40.54$, $P < 0.001$] and timepoint 1 [Wald $\chi^2(2) = 36.60$, $P < 0.001$], and the father had a significant influence on their children at timepoint 2, too (b = .15, $P = 0.024$). See Figure 4a for those path coefficients.

The quality of the relationship between the child and their parents is also shown to facilitate intergenerational transmission of values and norms.[23 25] To investigate this, as above, I fit a multiple group version of Model A in Figure 2 (Model B again failed to converge with multiple groups) whereby the parameters are allowed to differ for families which argued a lot before the pandemic versus which did not as much. Supporting a moderation effect, the parameters differ significantly across these two groups [LR $\chi^2(25) = 152.16$, $P < 0.001$]. Most importantly, maternal influence is stronger in families which did not argue as much than in families which argued more, both in the first (path coefficient = 0.64, $P < 0.001$ versus 0.20, $P < 0.001$, test of differences between coefficients: $\chi^2(1) = 67.80$, $P < 0.001$) and in the second lockdown; and in fact in the second lockdown maternal influence is statistically significant in families which did not argue much (path coefficient = 0.27, $P < 0.001$) while insignificant in families which argued more (path coefficient = 0.07, $P = 0.176$, difference in coefficients = 0.20, $\chi^2(1) = 14.56$, $P < 0.001$). See Figure 4b.

I then fit Model A in a multiple group framework for boys and girls separately. Results show that the path coefficients (the path from mother to child in timepoint 2 and that from father to child in timepoint 2, as well as that from the child to the mother and from the child to the father in both time points) do not differ significantly between boys and girls [LR $\chi^2(7) = 9.37$, $P = 0.227$]. However, at timepoint 1 mothers have an influence on daughters (b = 0.4, $P < 0.001$, 95% CI: 0.28-0.51) but no significant influence on sons (b = 0.1, $P = 0.152$, 95% CI: -0.05-0.30). See Figure 4c.

Robustness checks

Supplementary Results section 1 and Supplementary Figure 2 and 3 present the path coefficients estimated with robust standard errors, clustered at the household level as well as estimates obtained after applying survey weights. These alternative estimation methods do not alter the estimates and the conclusions in any substantial way.

Model A and B in Figure 2 control for earlier compliance in estimating effects on later compliance. Moreover, Model B includes household fixed effects that account for all time invariant covariates at the household level. Hence, Model A and B should largely address omitted variable bias. Nevertheless, I expand Model A and B by including several time-varying covariates, to mainly assess the robustness of parental influence to adjusting for key time-varying covariates. Research has identified several factors that affect compliance. These include political and interpersonal trust, perceived risks, and gender.[1 16 40] Supplementary Results section 2 and Supplementary Figure 4 show the estimated effects of the mother's and the father's compliance on the compliance of the child, alongside several covariates: trust in government and interpersonal trust, gender, whether the respondent had covid and has chronic illness, and the mode of the interview in time 2 (phone versus web). These estimates are obtained by expanding Model A and B, and in Model B, the household fixed effects are allowed to freely correlate with those exogenous variables. The results show that interestingly, taking the paths at timepoint 2 for example, political trust has a positive (b = 0.10, $P < 0.001$) while trust in people has a negative coefficient (b = -0.05, $P = 0.001$), women have higher compliance than men (b = 0.14, $P = 0.018$), having had covid strongly reduces compliance (b = -0.54,

$P < 0.001$), having a chronic illness increases compliance insignificantly (b = 0.07, $P = 0.219$), and those who were interviewed on the phone vis-à-vis web report higher compliance (b = 0.19, $P = 0.008$). Most importantly, these results show that parental influence estimates are virtually identical after controlling for these covariates (e.g., in Model A mother to child path is 0.140, $P = 0.001$ in timepoint 2 and 0.28, $P < 0.001$ in timepoint 1; the path from child's compliance at timepoint 1 to father's compliance at timepoint 2 is 0.07, $P = 0.005$).

Finally, Supplementary Results section 3 presents the results of analyses that check how much the results are robust to regional differences. Supplementary Figure 5 shows the path coefficients of Model A estimated with a multiple group framework whereby coefficients are allowed to vary in England on the one hand and Scotland, Wales, and Northern Ireland on the other (separate groups for each country did not converge due to relatively low N per country). While there are some differences between the two regions (e.g. mother to child path in time = 2 is stronger in England than in the other countries), the path coefficients are qualitatively similar between the two regions.

Discussion

Here I study, using longitudinal data and panel models, compliance with social distancing measures during the two lockdowns in the UK (May 2020 and February-March 2021). I do so analysing triplets that comprise the adolescent child (age 19), their mother, and father. Results show that adolescents have significantly lower levels of compliance with social distancing measures than their mothers and fathers, while mothers have the highest levels of compliance. Compliance is lower in the subsequent lockdown than the first lockdown for the children and their mothers, while for fathers there is no change. I should add though that compliance has been generally high for all groups, so the differences are relative.

In addition, I find that mothers, and when the child is living with their parents the fathers have a significant influence on their adolescent children's compliance with social distancing measures. These effects survive various alternative model setups and adjusting for key covariates, including lagged measures of the outcome, household fixed effects, and several time varying covariates.

Compared with mothers, fathers have smaller and mostly insignificant effects on their children's compliance, in keeping with the earlier results on parental influence.[19 22] This literature explains a stronger influence of mothers on their children compared with fathers by the propensity that mothers are often more involved in the children's activities in and beyond the home such as education and social events[22], and that mothers tend to interact more frequently with their children than fathers do.[19] In line with these explanations, I also find that living arrangements of the child moderate parental influence. For children who were at home during the lockdowns, parental influence is stronger and that the father too has a significant influence on their children, at least during the third lockdown. Likewise, the quality of relationship between the child and their parents also facilitates within-family influence on compliance.

Children too have significant effects on their father's and when they live with their parents also on mother's compliance. This influence from the child to their parents again resonates with past research which shows that particularly during late adolescence children have some influence on their parents, though a smaller one than parents have on them.[25]

A potential limitation is that I rely on self-reported measures of one's own compliance with social distancing. These self-reported measures may be optimistic or suffer from social desirability bias. However, given the difficulty of obtaining more objective measures of individual level compliance, it is inevitable to rely, at least until better measures are available, on these self-reported measures. In addition, there is item nonresponse and attrition in the survey which is a limitation (see Supplementary Table 1). However, missing data is handled through Full Information Maximum Likelihood which is shown to produce unbiased results under certain assumptions. Moreover, robustness checks have been conducted with survey weights which address nonresponse in an alternative way, and the results were similar.

The effects I find here correspond to around 10 to 30 percentage points changes in outcomes induced by a unit change in the independent variables, which are relatively modest. Nevertheless, during a pandemic even small improvements in compliance with public health measures may have strong long-term effects. This is not only because small but consistent behavioural improvements reduce the transmission risk in the long run but also behaviour can cascade through social networks whereby intergenerational transmission of compliance can reach peers beyond the immediate family through peer-to-peer interactions.[4 7 8 12]

Here I focus on parental influence on adolescents' compliance with public health measures during the COVID-19 lockdowns. Adolescents' and young adults' compliance with public health measures has been essential for controlling the pandemic. While this group has lower levels of compliance, they are often unfairly portrayed as "spreaders of the virus". [36] The parental influence on adolescents' compliance as well as the influence adolescents have on their parents I document here may redistribute some of the liability across all generations. Moreover, better public health campaigns could be developed by considering these family dynamics for the current pandemic and future epidemics. For example, parents can be reminded of their influence on their children and that young adults can be reminded of their influence on their parents' compliance with social distancing guidelines. Such campaigns can produce a powerful message: would one want their possibly vulnerable parents or children to be less protected against the virus due to their own lack of compliance with public health measures?

Methods

Data

The data used in this study are publicly available and collected after ethical approval and consent from the participants. Millennium Cohort Study follows a nationally representative sample of nearly 19,000 people born in the UK in 2000-02. Since the pandemic has started, a longitudinal UCL COVID-19 survey is implemented with the MCS respondents and their parents. The UCL COVID-19 survey takes place in three waves conducted respectively in May 2020, September-October 2020, and February-March 2021. Majority of the surveys are implemented online, but a minority of wave 3 respondents are interviewed via telephone. Waves 1 and 3 correspond with national lockdowns, hence compliance with social distancing measures is asked only in wave 1 and 3. I thus use these two waves (henceforth timepoint 1 and 2).

The parents of the MCS members are invited independently to take part in the survey. No explicit links are made between the parents and the MCS cohort members during invitation or data collection. Details of the UCL COVID-19 survey can be found elsewhere.[29 30]

Using pre-pandemic sweeps of MCS, I identify the child, their mother, and father in the COVID-19 survey. In particular, sweep 6 for parents has information on the relationship to the main cohort member, the gender of the parent, and a unique within household identifier of the parent and sweep 7 include a unique identifier for the main cohort member using which the parents and the main cohort members are linked with the UCL COVID-19 survey.

I exclude a small minority of individuals (2 percent, 409 cases) who are a different family member than the child, mother, or father participated (e.g. a grandparent, brother, or another relative or co-residing nonrelative). The resulting dataset comprise 6,752 child, mother, father triplets (~20,000 individuals) for whom at least one instance of non-missing compliance data exists.

The original MCS is nationally representative of the cohort. The effective sample of respondents who responded to the COVID-19 survey is diverse too, except for age—the adolescents were all at the age of 19/20 during the survey and their parents are of similar age due to being at a similar life stage. Of the adolescent respondents 60% are female and 20% are of non-White ethnic background. Average after-tax weekly total income of the respondent and their partner (if there is any) is reported as £184 by the adolescents and £992 by the parents.

Compliance with social distancing guidelines for each member of the is measured by the following item. “The next question is about the extent to which you are complying with the social distancing guidelines issued by the Government. On a scale from 0 to 10, where 0 means that you are 'not complying at all' and 10 means you are 'fully complying', how much would you say you are complying with the guidelines?” The question does not specify what social distancing guidelines are at the time of the survey.

Three variables are used as moderators in the additional results subsection, namely whether the child resided with their parents or away, the pre-pandemic relationship quality with parents, and the child’s gender. I now explain how I constructed those variables. Almost all adolescents reported to be living with their parents at timepoint 1 (91%). This ratio is 70% at timepoint two. A binary time-invariant variable is constructed if the child was staying away from their parents versus home at timepoint two. If this information is missing for an adolescent, the information on whether the child was living away from their parents versus home at timepoint 1 is substituted. Pre-pandemic relationship quality is constructed as follows. Sweep 6 of MCS asked “Most young people have occasional arguments with their parents. How often do you argue with your [mother | father]?” with answer categories 1 = Most days, 2 = More than once a week, 3 = Less than once a week, 4 = Hardly ever, 5 = Never. I compute an average arguing frequency with the mother and the father after reverse coding these items and create a binary variable by median split. Gender of the child is self-reported.

Estimation strategy

The number of observations in the waves of the UCL COVID-19 survey change due to new respondents joining at the newer waves or attrition (see Supplementary Tables for univariate statistics and information on missingness). To mitigate the potential effect of missingness on statistical power and bias, I implement Full Information Maximum Likelihood (FIML) estimation in fitting all models, including the model used to estimate descriptive statistics (means, variances, and the correlations of the key variables, see Table 1). FIML results in unbiased estimates under the assumptions that data are missing at random (i.e. missingness is accounted for fully by observed data) and distributed multivariate normally. It is furthermore shown to be rather robust to violations of the latter multivariate normality assumption.[41] The former assumption of missing at random is also plausible in this case, for the models rely on repeated measures of the outcome variable. In addition, in some model specifications I include household fixed effects which capture all observed and unobserved household-level time invariant confounders. These models make it more plausible to assume missingness to be at random conditional on household fixed effects and earlier or later measures of compliance.

The data are analysed with Stata version 17.0 (all SEM) and R version 3.6.1 (Figure 1).

Statistics and reproducibility

The study is based on the UCL COVID-19 survey which is a secondary data source collected independently from the author. The survey is conducted as an extension of an existing cohort study (Millennium Cohort Study); hence, no statistical method was used to predetermine the sample size. No data were excluded from the analyses, apart from family members who are not the focal child, mother, or father. The study does not involve a randomised experiment. The collectors of the data were unaware of the hypotheses tested in this study.

Data availability statement

Data used for this study are available here: https://osf.io/wucba/.

Code availability statement

The code developed for this study is available here: https://osf.io/wucba/.

Acknowledgements

I thank Deniz Aksoy for her comments on the earlier version of the figures.

Author contributions:

OA designed the research, analysed the data, and wrote the paper.

Competing interests:

The author declares no competing interests.

Tables

Table 1. Estimated sample moments. Means and variances of and correlations between compliance of the child, the mother, and the father across the two time points. Standard errors are given in parentheses. Sample moments are estimated with a model that includes these variables, their means, variances, and covariances using Full Information Maximum Likelihood. N = 6,752. ** *P* < 0.01, * *P* < 0.05 for two-sided $\chi^2(1)$ tests without adjustments for multiple comparisons. CC (1) = Child compliance (t = 1), …, FC (2) = Father compliance (t = 2).

	CC (1)	CC (2)	MC (1)	MC (2)	FC (1)	FC (2)
Child compliance (t = 1)	1					
Child compliance (t = 2)	.342** (.020)	1				
Mother compliance (t= 1)	.221** (.035)	.120** (.028)	1			
Mother compliance (t = 2)	.156** (.029)	.144** (.021)	.324** (.024)	1		
Father compliance (t = 1)	.084 (.050)	.076* (.035)	.089 (.056)	.150** (.042)	1	
Father compliance (t = 2)	.242** (.044)	.144** (.022)	.123** (.046)	.282** (.032)	.553** (.029)	1
Means:	9.015 (.026)	8.133 (.029)	9.380 (.023)	9.300 (.020)	9.083 (.041)	9.116 (.029)
Variances:	1.881 (.052)	3.655 (.079)	1.064 (.035)	1.334 (.033)	1.683 (.082)	1.618 (.055)

Table 2. Unstandardised SEM results. Direct paths, covariances between mother's and father's compliance in each timepoint, and variance of the latent household fixed effects for models in Figure 2. Variances of residuals and of exogenous observed variables and means/intercepts are suppressed for brevity. Fit measures are included below which indicate reasonable fit for Model A (model χ^2 is only significant at the 0.01 level despite relatively large N, RMSEA is well below 0.05, both CFI is above and TLI is close to 0.95) and near perfect fit for Model B (model χ^2 is insignificant, RMSEA is effectively zero, CFI and TLI are both 1). A χ^2 test of the two models and AIC favour Model B against Model A, BIC favours Model A against Model B. For 95% Confidence Intervals see Figure 3.

	Model A b (se) [2-sided *P*]	Model B b/se [2-sided *P*]
Compliance child (t=2) regressed on		
Compliance mother (t=2)	.132 (.043) [.002]	.057 (.048) [.235]
Compliance father (t=2)	.045 (.066) [.494]	-.026 (.068) [.707]
Compliance child (t=1)	.440 (.033) [.000]	.398 (.035) [.000]
Compliance mother (t=1)	.032 (.058) [.577]	-.034 (.063) [.595]
Compliance father (t=1)	.034 (.069) [.621]	.006 (.070) [.936]
Household fixed effect (latent)		1.000
Compliance mother (t=2) regressed on		
Compliance child (t=1)	.077 (.025) [.002]	.010 (.033) [.769]
Compliance mother (t=1)	.340 (.028) [.000]	.240 (.050) [.000]
Household fixed effect (latent)		1.000
Compliance father (t=2) regressed on		
Compliance child (t=1)	.187 (.038) [.000]	.102 (.048) [.035]
Compliance father (t=1)	.510 (.030) [.000]	.447 (.040) [.000]
Household fixed effect (latent)		1.000
Compliance child (t=1) regressed on		
Compliance mother (t=1)	.285 (.047) [.000]	.170 (.065) [.010]
Compliance father (t=1)	.073 (.054) [.177]	-.002 (.064) [.973]
Household fixed effect (latent)		1.000
cov($CompMother_2$, $ComFather_2$)	.278 (.046) [.000]	.141 (.064) [.027]
cov($CompMother_1$, $ComFather_1$)	.175 (.070) [.013]	-.022 (.101) [.830]
variance(Household FE (latent))		.133 (.052) [.000]
Fit measures		
Model χ^2(df) *P*	7.665 (2) *P* = .022	2.065 (1) *P* = .151
RMSEA (90% CI)	.020 (.007-.037)	.013 (.000-.038)
CFI/TLI	.992/.943	.998/.977
AIC	51404.438	51400.837
BIC	51574.878	51578.095
N	6752	6752

Figure titles and legends

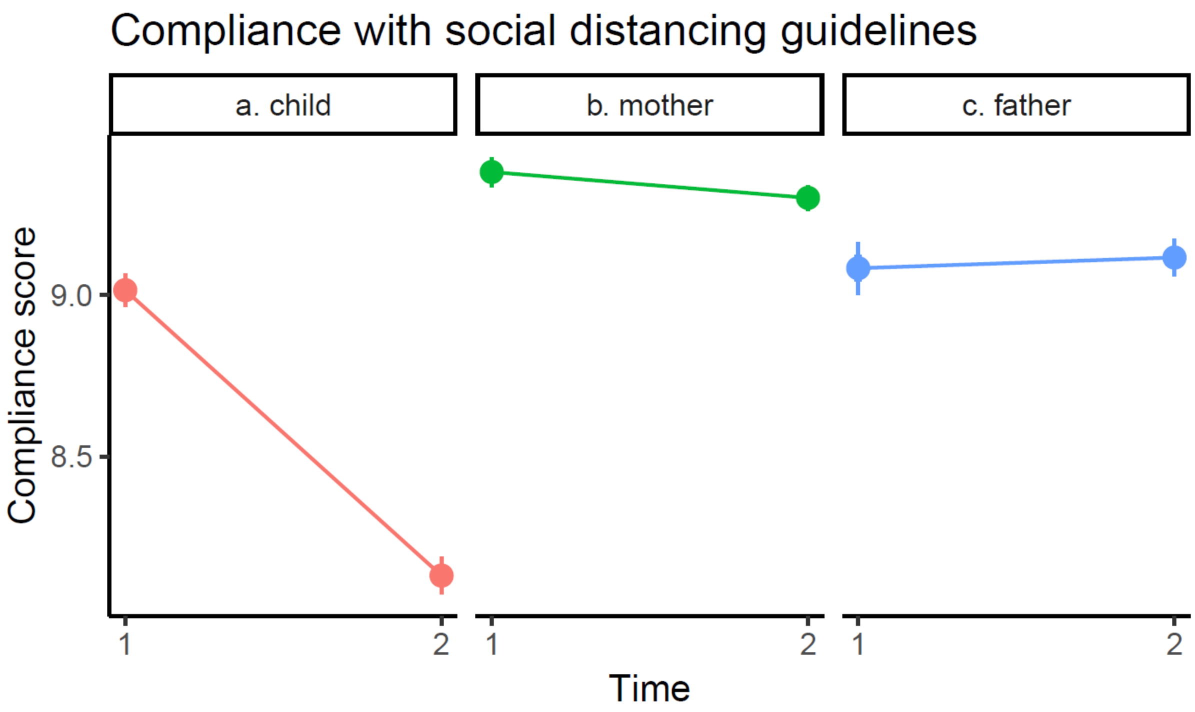
Figure 1. Compliance with Social Distancing Guidelines. Average compliance among the child, mother, and the father at the two time points (first lockdown and the third lockdown). 95% Confidence Interval is included. Means are estimated with Full Information Maximum Likelihood (N = 6,752).

Figure 2. Longitudinal Structural Equation Models of Parental Influence. Comp = Compliance with social distancing; subscript indicate timepoint. Panel a: baseline model (Model A), Panel b: extended model with household fixed effects (Model B).

Figure 3. Path Coefficients in Model A and B. Midpoints represent unstandardised coefficients of the models in Figure 2a and 2b (N = 6,752), e.g. the first estimate (Comp Child (t=2) on Comp Mother (t=2)) shows the path coefficient from the mother's compliance at time 2 on the child's compliance at time 2. 95% Confidence Interval is included.

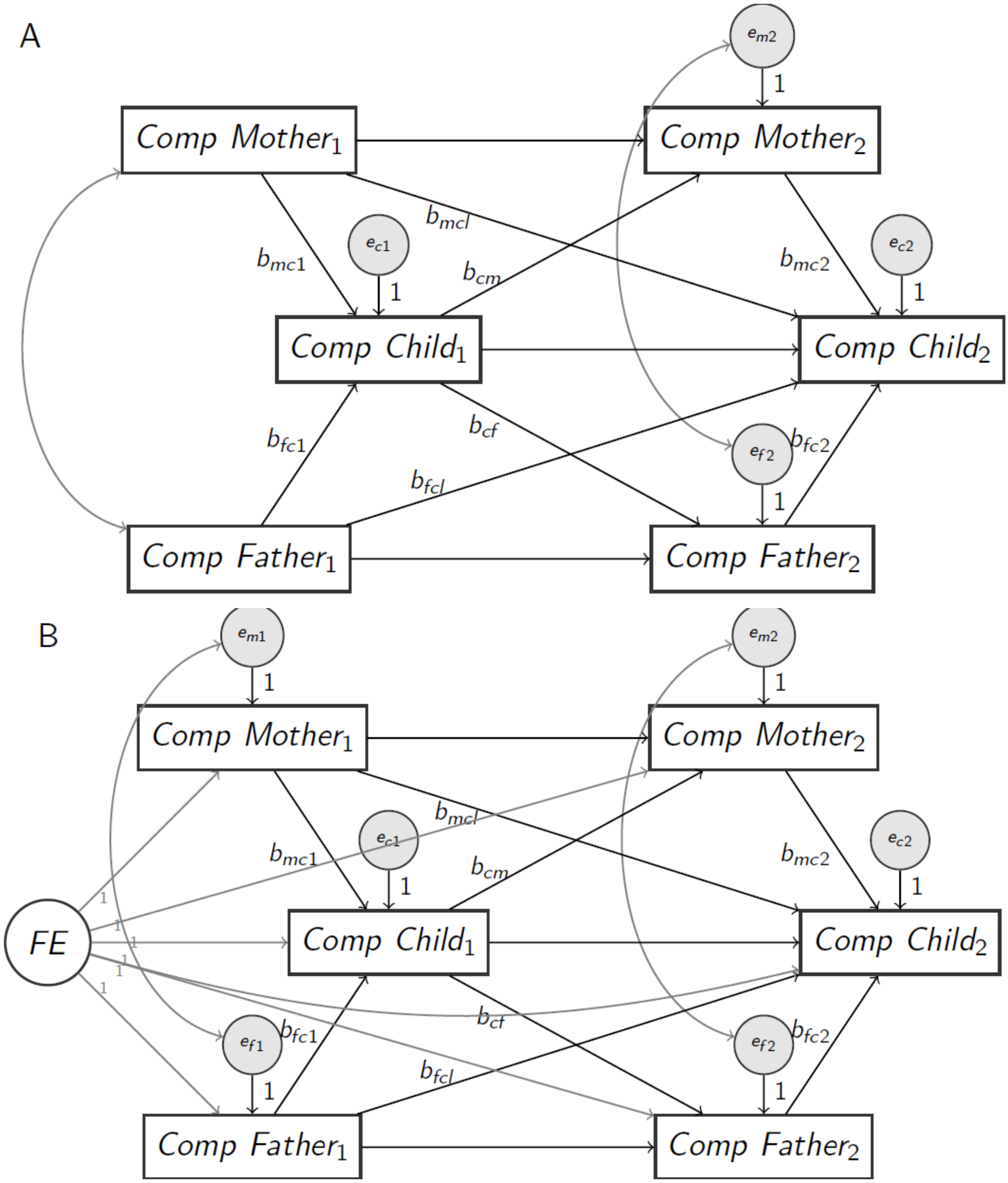
Figure 4. Moderators of within Family Influence. Midpoints represent unstandardised coefficients of the models in Figure 2a fitted with a multiple group framework whereby parameters are allowed to vary across different types of families. Panel a compares families for which the child was away versus at home during the lockdown; panel b compares families which argue more versus less frequently than the sample median; panel c compares families with daughters versus sons as the adolescent respondent. 95% Confidence Interval is included.

Figure 1



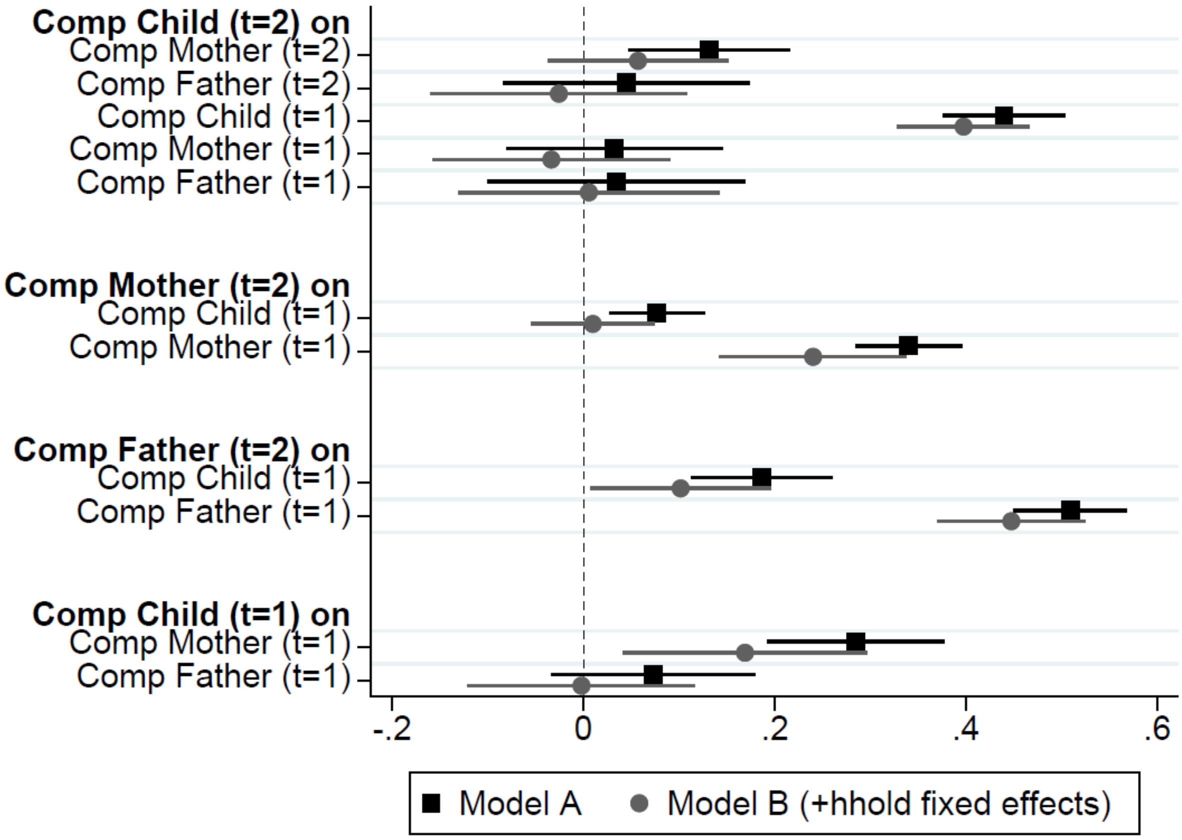
Compliance with social distancing guidelines
a. child
b. mother
c. father
Compliance score
9.0
8.5
1
2
1
2
1
2
Time

Figure 2



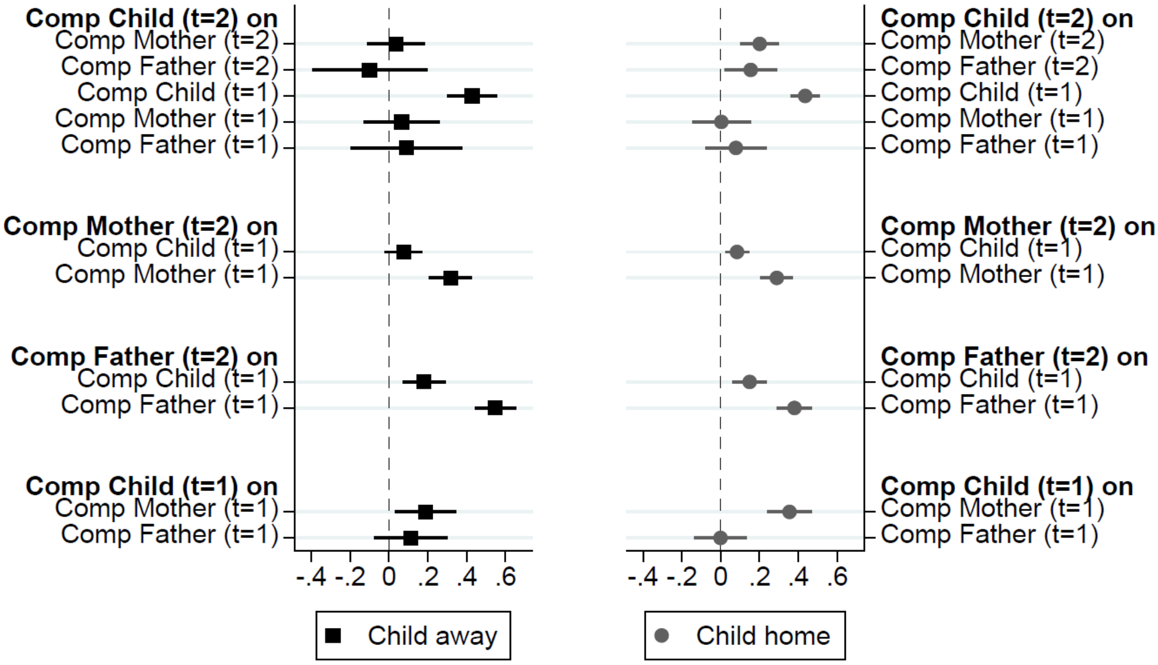
A
e_{m2}
1
$Comp\ Mother_1$
$Comp\ Mother_2$
b_{mcl}
b_{mc1}
e_{c1}
1
b_{cm}
b_{mc2}
e_{c2}
1
$Comp\ Child_1$
$Comp\ Child_2$
b_{fc1}
b_{cf}
e_{f2}
b_{fc2}
b_{fcl}
1
$Comp\ Father_1$
$Comp\ Father_2$
B
e_{m1}
1
e_{m2}
1
$Comp\ Mother_1$
$Comp\ Mother_2$
b_{mcl}
b_{mc1}
e_{c1}
b_{cm}
1
b_{mc2}
e_{c2}
1
FE
$Comp\ Child_1$
$Comp\ Child_2$
b_{cf}
e_{f1}
b_{fc1}
e_{f2}
b_{fc2}
b_{fcl}
1
1
$Comp\ Father_1$
$Comp\ Father_2$

Figure 3



Comp Child (t=2) on
Comp Mother (t=2)
Comp Father (t=2)
Comp Child (t=1)
Comp Mother (t=1)
Comp Father (t=1)
Comp Mother (t=2) on
Comp Child (t=1)
Comp Mother (t=1)
Comp Father (t=2) on
Comp Child (t=1)
Comp Father (t=1)
Comp Child (t=1) on
Comp Mother (t=1)
Comp Father (t=1)
-.2
0
.2
.4
.6
Model A
Model B (+hhold fixed effects)

Figure 4



Comp Child (t=2) on
Comp Mother (t=2)
Comp Father (t=2)
Comp Child (t=1)
Comp Mother (t=1)
Comp Father (t=1)
Comp Mother (t=2) on
Comp Child (t=1)
Comp Mother (t=1)
Comp Father (t=2) on
Comp Child (t=1)
Comp Father (t=1)
Comp Child (t=1) on
Comp Mother (t=1)
Comp Father (t=1)
-.4 -.2 0 .2 .4 .6
-.4 -.2 0 .2 .4 .6
Child away
Child home

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Supplementary Information: “Within family influences on compliance with social distancing measures during Covid-19 lockdowns in the UK”

Ozan Aksoy[1*]

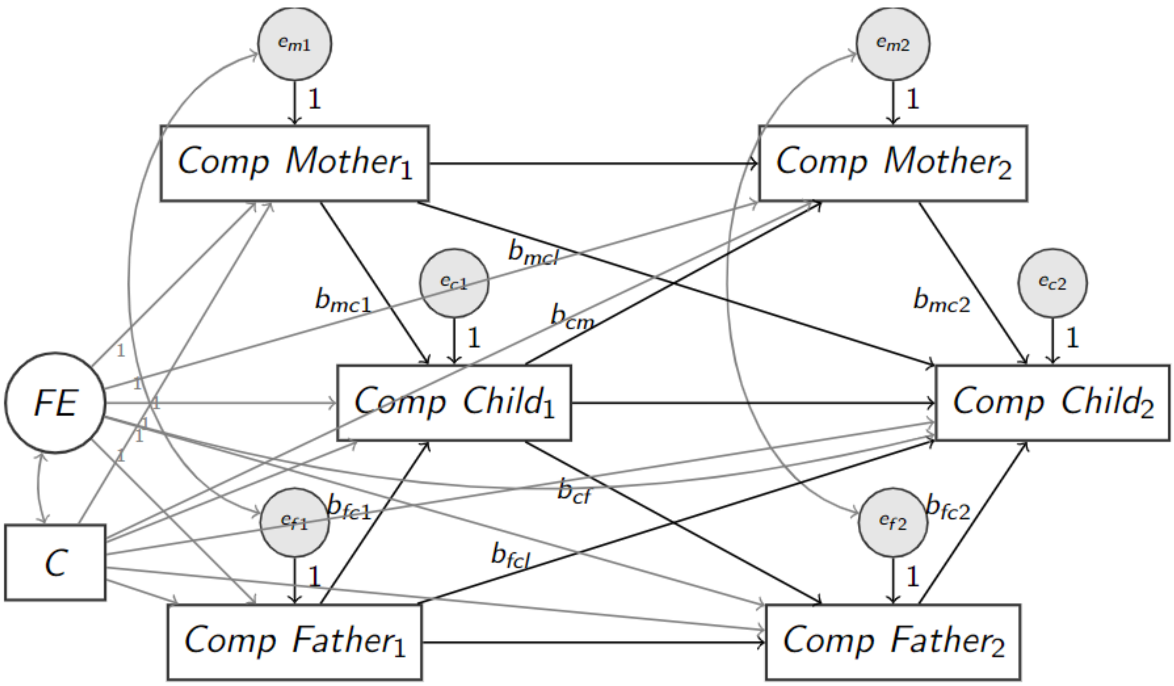
[1]UCL Social Research Institute, University College London, 55-59 Gordon Square, WC1H 0NU, London UK
*email address for correspondence: ozan.aksoy@ucl.ac.uk

Contents

Supplementary Methods

1. Fixed effects panel models with covariates

Supplementary Figure 1 below illustrates the specification of the model with household fixed effects when control variables are included in the model. In Supplementary Figure 1 a generic control variable C, which would be a single or a set of time varying or time invariant variable(s) at the individual or household level, is included in the model. C is allowed to correlate with the latent household fixed effect (FE) and has paths on all endogenous outcome variables.



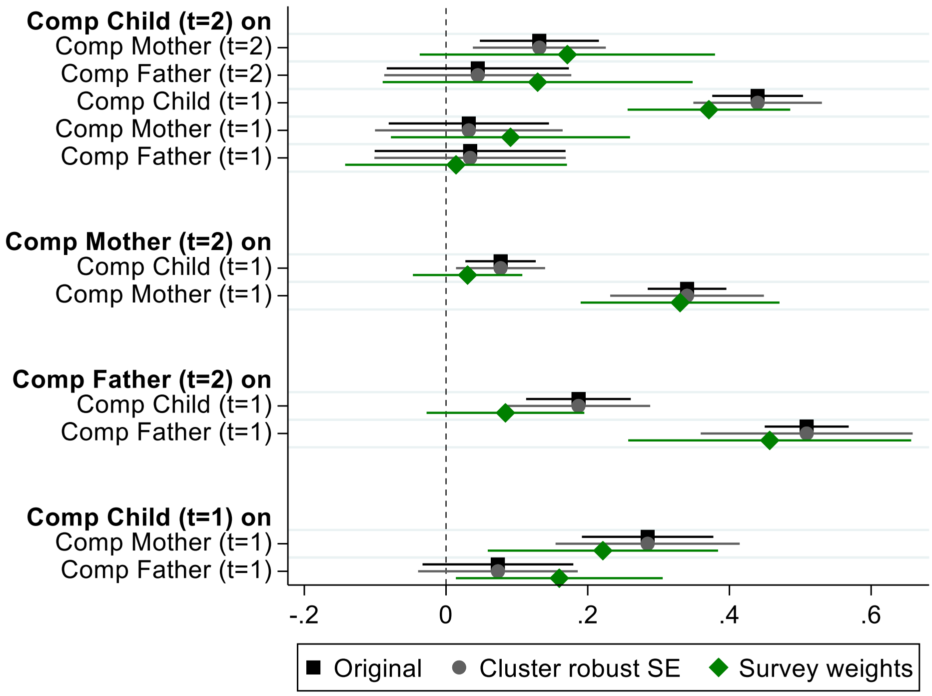
Supplementary Figure 1. Illustration of the model specification with household fixed effects with a generic control variable C.

Supplementary Results

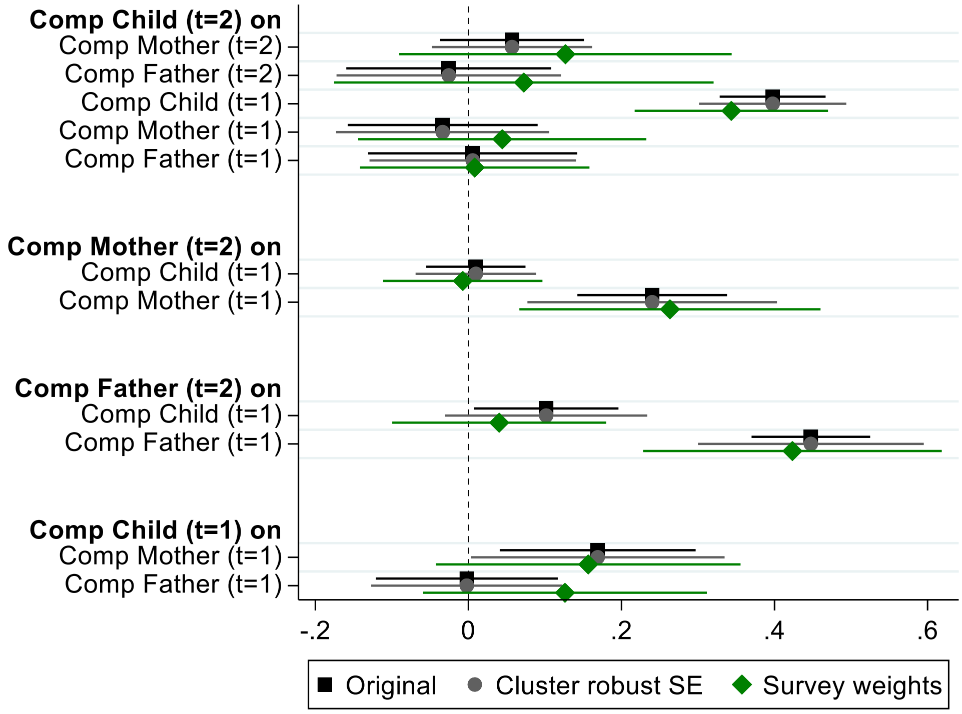
1. Robust standard errors and survey weights

Supplementary Figure 2 and 3 present the path coefficients and 95% CIs of Model A and Model B, respectively using three alternative specifications: (1) those reported in the main manuscript (2) with cluster robust standard errors (3) with survey weights applied. Survey weights is complicated in this case, hence how these are obtained require an explanation. In the original survey, weights are reported independently for each wave, and no longitudinal weight is reported. This means that it is not possible to use weights in the cross-lagged panel models I fit. Nevertheless, as a first approximation, I calculate a longitudinal weight based on the *mean* weight, i.e., average of the three weights reported for the three waves of the survey (missing values omitted in calculating this average). In the weighted estimates below in Supplementary Figure 2 and 3 this mean weight is used. This is not an ideal way of calculating longitudinal weights but is the only one available for the moment.

The reasons for checking robust standard errors as well as survey weights is as follows. Cluster robust standard errors may adjust dependence within household better than the default standard errors, although cluster robust standard errors are generally more conservative. Survey weights help improve external validity of the results, recovering the representativeness of the sample by weighting cases according to their ratios in the population. However, survey weights may also reduce statistical precision. As the figures below show the application of robust standard errors or survey weights to not alter the results in substantive ways which is reassuring.



Supplementary Figure 2: Path coefficients in Model A (95% CI) reported in the main manuscript plus those obtained with cluster robust standard errors and survey weights (N = 6,754 for original and cluster robust SE; 5,211 for the model with survey weights).



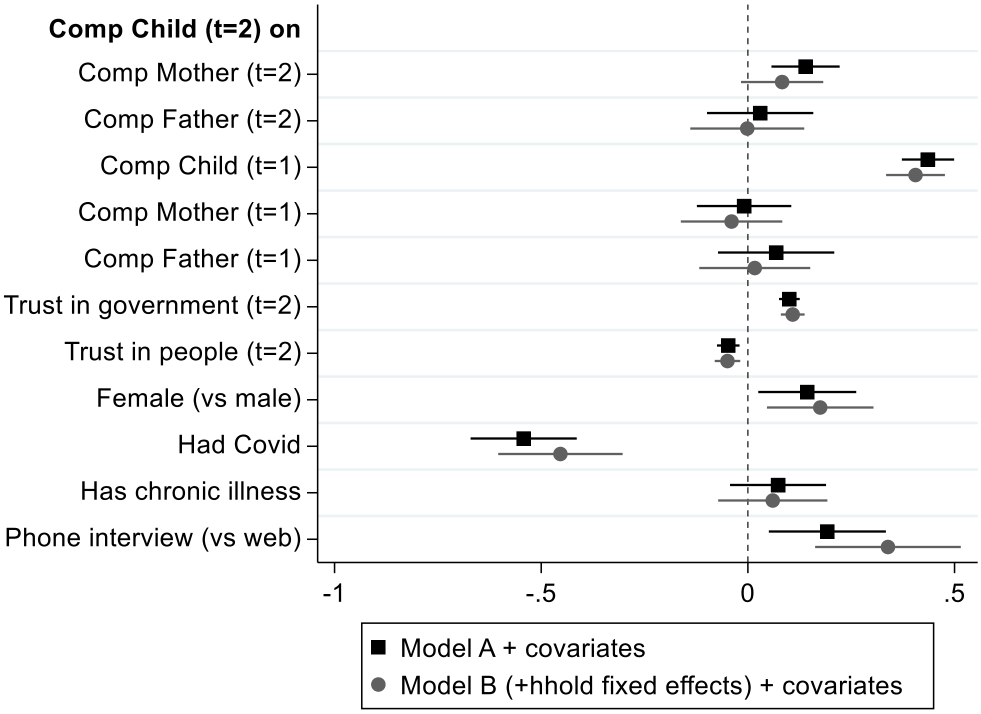
Supplementary Figure 3: Path coefficients in Model B (95% CI) reported in the main manuscript plus those obtained with cluster robust standard errors and survey weights (N = 6,754 for original and cluster robust SE; 5,211 for the model with survey weights).

2. Time varying covariates

Here I expand Model A and B in Figure 2 by including the following time-varying covariates:

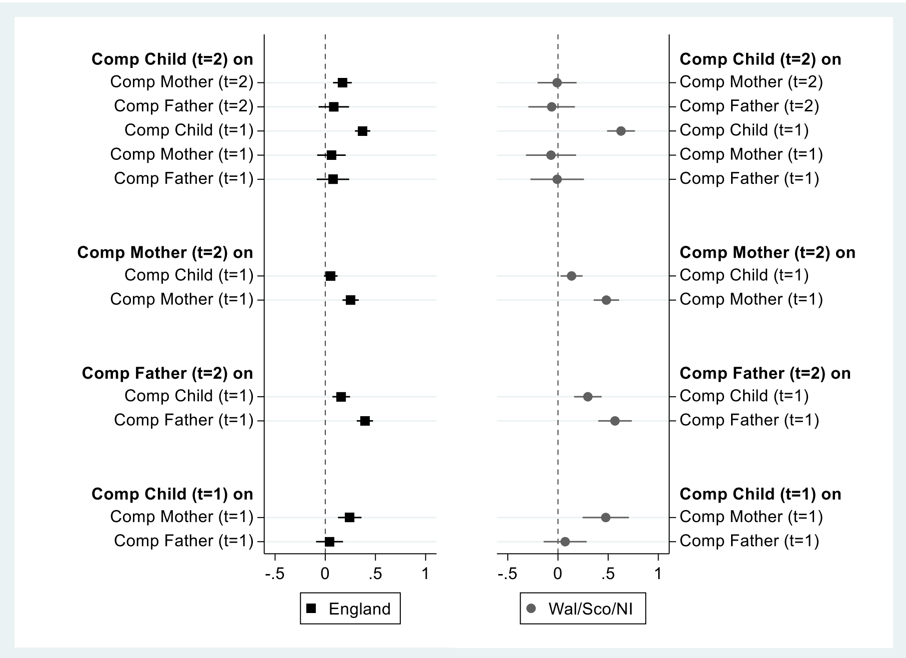
- *trust in government* (“On a scale from 0-10 where 0 means you are 'not at all trusting' and 10 means you are 'extremely trusting', how trusting are you that British Governments, of any party, place the needs of the nation above the needs of their own political party”, with answers 0 = not at all trusting to 10 = extremely trusting),
- *interpersonal trust* (“On a scale from 0-10 where 0 means you are 'not at all trusting' of other people and 10 means you are 'extremely trusting' of other people, how trusting of other people would you say you are”, with answers 0 = not at all trusting to 10 = extremely trusting),
- *gender* (men or women),
- whether the respondent *had covid* (if the question “Do you think that you have or have had Coronavirus?” is answered either of the following: (1) Yes, confirmed by a positive test (2) Yes, based on strong personal suspicion or medical advice),
- *has chronic illness* (if the respondent reported to having any of the following: Cancer, Cystic fibrosis, Asthma, Chronic Obstructive Pulmonary Disease, Wheezy bronchitis, Diabetes, Recurrent backache, prolapsed disc, sciatica or other back problem, Problems with hearing, High blood pressure, Heart disease, congenital or acquired, Depression or other emotional, nervous or psychiatric problems, Obesity, Chronic obstructive airways disease, Infection, HIV / Immunodeficiency, Condition affecting the brain and nerves (e.g. Parkinson’s, Multiple Sclerosis)), and
- the *mode of the* interview in time 2 (phone versus web).

In the models, I include these covariates measured in timepoint 1 and timepoint 2 as predictors of compliance in timepoint 1 and timepoint 2, respectively, for each member of the child/mother/father triplet. Supplementary Figure 4 shows the path coefficients only for timepoint 2 for simplicity (estimates for timepoint 1 are similar). Results show that (Supplementary Figure 4) trust in people has a negative coefficient, political trust has a positive coefficient on compliance, males have lower compliance than females, having had covid reduces a chronic illness increases compliance, and those who were interviewed on the phone versus web show higher compliance. Importantly, parental influence coefficients are basically identical after controlling for covariates.



Supplementary Figure 4: Unstandardised path coefficients in Model A and Model B (95% CI) that are expanded by including several time-varying covariates (N = 7080).

3. Geographic variation in path coefficients



Supplementary Figure 5: Unstandardised path coefficients in Model A (95% CI) estimated with a multiple group framework whereby coefficients are allowed to vary in England on the one hand and Scotland, Wales, and Northern Ireland on the other (N = 4626).

Supplementary Tables

*Supplementary Table 1: Pattern of missingness by respondent type.**

Pattern (total N(triplets) = 6752)	Child	Mother	Father
Both waves non-missing	1979	1463	646
Non-missing in t = 1 & missing in t = 2 (attrition)	625	469	245
Missing in t = 1 & non-missing in t = 2 (new joiner)	2390	1912	1158

*Note, in the main manuscript the models including that used to estimate descriptive statistics are fitted with Full Information Maximum Likelihood which includes all cases (N = 6752) that include at least one non-missing case for any of the member of the child, mother, father triplet for any wave.

Supplementary Table 2: Univariate descriptive statistics and the number of cases.

Variable	N	Mean	Min	Max	SD
Compliance child (t = 1)	2604	9.00	0.00	10.00	1.37
Compliance child (t = 2)	4369	8.15	0.00	10.00	1.91
Compliance mother (t = 1)	1932	9.38	0.00	10.00	1.03
Compliance mother (t = 2)	3375	9.30	0.00	10.00	1.51
Compliance father (t = 1)	891	9.12	0.00	10.00	1.26
Compliance father (t = 2)	1804	9.13	0.00	10.00	1.27