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Preventing youth depression: simulating the impact of parenting interventions

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Highlights

- We construct a simulation model of the early life course.
- The model integrates data from empirical sources including meta-analytic estimates.
- We test potential interventions on parenting behaviors to reduce youth depression.
- We show socio-economic gradients in effectiveness.
- We develop and provide a publicly accessible research tool for policy makers.

Abstract

Depression is an increasing global problem, and was the leading cause of disability in 2015. Much is known about the factors that give rise to depression, and social inequalities in its prevalence, but less

about empirically based interventions that might prevent its occurrence. We focus on the role of maternal parenting factors (that is emotional warmth and harsh discipline) experienced in childhood affecting depression in youth (aged 15 to 21 years) in New Zealand. We introduce a novel simulational life-course approach. We use estimates from meta-analytic reviews on the effects of maternal parenting factors to drive a simulation model of the early life course. We then mimic possible interventions by testing scenarios based on modifying these key factors and assessing their impact on depression. We find that reduction in depression prevalence is better achieved by altering a combination of rather than single maternal parenting factors, and that the social groups in which youth are structurally embedded (by parental social position) are differentially affected. In the most optimistic scenario, if both lack of emotional warmth and harsh discipline could be completely eliminated in childhood, our model shows that youth depression overall (baseline 7.4%) would be reduced by about a fifth (to 5.8%), while the greatest improvement would accrue to youth who had parents without formal educational qualifications (baseline 11.3%) by nearly a third (to 7.7%). Our findings support the utility of our approach for policy making on population health issues, in this case, indicating maternal parenting interventions that might be effective in preventing youth depression and the social groups that might gain most benefit.

Keywords: life course, simulation, depression, youth, parenting, inequalities

Introduction

Depression is an increasing world-wide problem, ranked by the World Health Organization as the leading contributor to global disability in 2015 (World Health Organization, 2017). In that year, the global prevalence of depression among youth (aged 15-19 years) was estimated to be 4.5% in females and 3.2% in males (World Health Organization, 2017). Against this backdrop, the mental health of youth has become a pressing public health issue (Kieling et al., 2011). The most recent information from New Zealand (NZ) in 2015/16 shows that 8.6% of youth (aged 15-24) suffered with major depressive disorder (Ministry of Health, 2016), while, in 2003/4, the lifetime prevalence in youth (aged 16-24) was estimated to be 15.1% (Oakley Brown, Wells, & Scott, 2006). In 2012, 12.8% of NZ secondary school students reported clinically significant depressive symptoms in the last 12 months, while 31.1% of students

reported feeling depressed most of the day for at least two consecutive weeks in the last 12 months (Adolescent Health Research Group, 2013).

Adolescence is a critical developmental period (Beardslee, Gladstone, & O'Connor, 2012; Ben-Shlomo & Kuh, 2002). The brain and body systems develop substantially in this period of life (Corna, 2013). Healthy adolescents are not only more likely to grow into healthy adults, they are also more likely to have greater economic security and stability in adulthood. Psychosocial health problems are most likely to emerge during adolescence (Braveman, 2014). Depression occurring at this intermediate life stage has continuing adverse consequences for their later trajectory as youth develop from children into adults (Meeus, 2016). In this respect, a life-course perspective is advantageous in accounting for both lagged and concurrent influences that may persist or accumulate over time (Reiss, 2013; Landry, Smith, Swank, & Guttentag, 2008), and in understanding the generation of social inequalities in health (Fuhrmann, Knoll, & Blakemore, 2015; Kessler et al., 2005). Further down the track, most crucially for their life chances, depressed youth are more likely to have worse social and economic outcomes as adults (Sawyer et al., 2012). In terms of changing the precursors to, and thereby preventing, youth depression, a life-course perspective points to, for example, early parenting intervention in childhood for maximum impact (Viner et al., 2012).

Parental behaviors toward offspring have been shown variously to be either protective or risk factors for depression (Chapman, Parkinson, & Halligan, 2016; Schwartz, Sheeber, Dudgeon, & Allen, 2012). Maccoby and Martin (1983) characterized these parental behaviors along the two dimensions of being responsive, and being demanding towards their child, to form a four-fold typology of parenting style. Thus according to the authoritative type, held to be the optimal style, the parent is both highly responsive – i.e. being nurturing, encouraging and warm towards their child - and highly demanding – i.e. having expectations of and setting limits for their child, along with fair and reasonable discipline. Across all cultures, parenting styles have been shown to vary by socio-economic position. For example, Hoff, Laursen, & Tardiff (2002) found that parents in lower socio-economic positions are more likely to use 'authoritarian' (non-responsive and demanding) parenting styles, than those in higher socioeconomic positions. Low income parents are also more likely to use inconsistent, erratic and harsh discipline. Katz, Corlyon, La Placa, & Hunter (2007) describe three main theories as to why socio-economic

conditions affect parenting: stress, culture of poverty, and the environment. The 'parental stress' theory advanced by Conger, Patterson, & Ge (1995) suggests that economic strain increases parental stress levels leading to poorer spousal relationships, distress, and depression resulting in poorer parenting practices. Parents who are stressed are less likely to be able to provide optimal home circumstances. The 'culture of poverty' theory states that parents living in poverty form a different 'culture' to that of better-off parents (Lewis, 1966). This culture includes low expectations for children, an emphasis on conformity, and the use of physical rather than verbal methods of punishment. Parenting styles form part of this culture and are transmitted from one generation to the next, contributing to the cycle of poverty (Fram, 2003). The 'environment' theory asserts that parenting style is affected by neighbourhood characteristics as well as personal characteristics. Neighbours can influence one another's behavior through the "contagion" effect - whereby behaviors are learned and copied – or by 'collective socialisation' - whereby communities have social norms and rules about acceptable behavior (Jencks & Mayer, 1990). In particular, it has been found that parenting style affects adolescent outcomes, and that this is moderated by the socio-cultural settings inhabited by families (Hoskins, 2014; Milevsky, Schlechter, Netter, & Keehn, 2007). Thus, children and youth from impoverished families are more likely to be exposed to harmful parental behaviors and become vulnerable to experiencing depression (Bambra et al., 2010; Duncan & Magnuson, 2013; Pascoe, Wood, Duffee, & Kuo, 2016; Sawyer et al., 2012).

Despite the existing evidence, there are few demonstrations of family-based intervention strategies that show their positive impact on reducing youth depression, and that identify the affected social groups they could help (Das et al., 2016; Gladstone, Beardslee, & O'Connor, 2011; Restifo & Bogels, 2009; Yap et al., 2016; Young & Fristad, 2015). Accessible information of this kind is essential for the translation of research into effective policy. Allied with a life-course approach, simulation modelling is an important methodology for filling the practical need to support policy-making (Gilbert, Ahrweiler, Barbrook-Johnson, Narasimhan, & Wilkinson, 2018), and in particular to evaluate the impact of population health interventions (Smith, Smith, Harper, Manuel, & Mustard, 2014). It assumes a counterfactual-manipulative interpretation of causality where timing is paramount; for example, in posing a counterfactual scenario, if an intervention is able to alter the outcome, then the manipulated risk factor may be considered to be causal (Campaner, 2011). Hence, if parenting style can somehow

be improved in childhood, and forward simulation shows that the prevalence of depression is thereafter diminished in adolescence, then the change in parenting style may be deemed the cause of the change in depression. Modelling of this kind can be usefully employed to identify actions that might lead to positive potential outcomes, and thus contribute to policy development.

Simulation models are increasingly used in population health, including the estimation of depression prevalence (Patten, Gordon-Brown, & Meadows, 2010). In this paper, the type of model constructed is the discrete-time dynamic microsimulation model applied to a health outcome (Rutter, Zaslavsky, & Feuer, 2011; Zucchelli, Jones, & Rice, 2012). Derived from real data, this model involves replicating a particular population of individuals and their attributes (i.e. the 'starting sample'), and following that population as it would evolve over time (i.e. the 'simulation'), for example, tracking a cohort of children through the early life course. For the simulation process to proceed, we need parameters (i.e. a set of rules) to govern the transition of each individual in the starting sample as they move through life's stages along their own distinct trajectory. This forward simulation may be informed in various ways, including the use of regression estimates of associations from research studies (as we will do here). The key technical advantage of this simulation approach is the ability to simultaneously handle multiple associations in a single model (Smith, Smith, Harper, Manuel, & Mustard, 2014), performing analytical tasks that may not be possible by conventional means. Simulation modelling has particular policy relevance as initial settings (regarding both baseline data and baseline transition parameters) can be manipulated to test scenarios, for example, in mimicking the introduction of an intervention and assessing its impact on an outcome. Thus, virtual experiments can be carried out to evaluate policy alternatives in timely fashion without the costs incurred and ethical issues encountered in field implementation.

The aim of this study was to draw together up-to-date evidence from the international literature to inform a simulation model of the early life course, and then to use it to test possible interventions to reduce depression in youth aged 15-21 years. While baseline data came from NZ sources, we gathered effect estimates from meta-analyses (deemed to be 'best estimates') that combine results from several independent studies and so improve the accuracy and precision of estimates (Ogilvie, Hamilton, Egan, & Petticrew, 2005). Our study sought to answer the following research questions:

1. What is the effect of improving either single or combined *maternal parenting behaviors* on the prevalence of youth depression?

2. What is the impact of improvements in maternal parenting behaviors on the prevalence of youth depression by *social group*?

Methods

Essentially, we developed a synthetic representation of the early life course, using real data, which we then harnessed for an applied purpose. The content of our model was informed by stakeholders, namely representatives of government agencies, with the view to answering some of their policy questions. Here, we summarise aspects specifically related to our study of youth depression. A description of the general methods regarding our simulational life-course approach is elaborated elsewhere (Milne, Lay-Yee, von Randow, & Davis, 2015; Milne et al., 2017).

Conceptual framework

For a variable to be included in the framework, three criteria needed to be satisfied: (a) an estimate derived from a meta-analysis of the relationship between the variable and youth depression; (b) a NZ-specific base rate for each variable; and (c) information on the joint distribution between variables. A literature search was undertaken in June 2016 of relevant databases: PubMed, Cochrane Library, PsycInfo, and Eric. We found two recent meta-analytic reviews on youth depression for variables that met our three inclusion criteria: Yap, Pilkington, Ryan, and Jorm (2014) regarding the positive effect of parental warmth (odds ratio 0.47), and Norman et al. (2012) regarding the negative effect of physical abuse (odds ratio 1.54) (see Table 1).

Insert Table 1 here

Data sources

The starting sample for our simulation was a synthetic birth cohort of new-borns (n=5,000) whose characteristics closely matched those of 0-year olds in the 2006 NZ Census of Population and Dwellings (Statistics NZ, 2014). These data were augmented from three NZ longitudinal birth cohorts: Christchurch Health and Development Study, Dunedin Multidisciplinary Health and Development Study, and Pacific Island Families Study (Milne, Lay-Yee, von Randow, & Davis, 2015). Our study involved the secondary use of existing data sources, so did not require ethical approval.

Description of variables

Outcome:

We simulated propensity for depression to match age-, gender-, and ethnicity-specific prevalences as reported in the 2015/16 NZ Health Survey (Ministry of Health, 2016) which asked: 'Have you ever been told by a doctor that you have depression? *Yes / No.'* These data were available for the age-band 15-24 years; as an approximation, we used linear interpolation to create a prevalence estimate for every year of age from 15 to 21 (our defined period of adolescence) since the NZ Health Survey data suggested that depression peaks at 35-44 in women, and 45-54 in men, with increasing prevalence from age 15 up to these ages. Adjusted rate ratios for the difference in prevalence by gender and ethnicity were used to allow for different model intercepts.

Social groups (fixed):

These were defined by structural factors, operationalized as two measures of parental social position at the time of the birth of the child.

a) Parental education level - recorded in the 2006 NZ Census (Statistics NZ, 2014). In two-parent households, we used the higher level attained between parents. Categories were: no formal qualifications; secondary qualifications; and tertiary level qualifications.
b) Parental socio-economic status – sourced from NZ longitudinal studies (Milne, Lay-Yee, von Randow, & Davis, 2015), based on main provider's occupation: semi-skilled, unskilled, unemployed; clerical, technical, skilled; and professional, managerial (Elley & Irving, 1976).

Maternal parenting factors (modifiable):

Two components of parenting style were constructed as risk factors, modelled to match the distribution found in the Christchurch Health and Development Study (ages 3-5) which used the HOME inventory (Totsika & Sylva, 2004).

a) Maternal lack of emotional warmth (*Yes / No)* – extent to which the mother was not attuned to the child's needs and did not respond in a warm manner, using the 'emotional responsivity' scale – examples of items are: 'parent holds child close for 10-15 minutes per day'; 'parent converses with child at least twice during visit' (Totsika & Sylva, 2004: page 26). Scale scores ranged from 0-10; a cut-off score <7 was used to indicate lack of warmth.

b) Maternal harsh discipline (*Yes / No)* – extent to which the mother utilized a restrictive and punitive form of discipline, using the 'restriction and punishment' scale – examples of items are: 'primary caregiver does not shout at child during visit'; 'primary caregiver does not express overt annoyance with or hostility about the child' (Totsika & Sylva, 2004: page 26). Scale scores ranged from 0-5; a cut-off score >1 was used to indicate harsh discipline. Note that we could not find a meta-analytic estimate specifically for the association between harsh discipline and depression, but used one found for physical abuse and depression (Norman et al., 2012) as a near proxy.

For the purposes of later scenario testing, we defined a 'high-risk group' in the starting sample, i.e. a group of individuals where at least one of the maternal parenting factors was present.

A description of the starting sample can be found in Table 2. The percentage who had depression steadily increased from 5.4% at age 15 to 8.7% by age 21, averaging 7.4%. In terms of maternal parenting, at age five, 15.7% of children were experiencing a lack of emotional warmth while 22.2% experienced harsh discipline. Of their parents, 34.7% were in the lowest socio-economic status group, and 7.6% had no formal education.

Insert Table 2 here

Simulation

Before the simulation process can begin, we require a starting sample (described above) and input parameters to inform the evolution of that sample over time. Depression was simulated using a logistic

regression framework, the function for which is a conditional Bernoulli distribution. Thus, the probability of being depressed can be defined as:

$$P(Depressed = Yes \,|x_1, \dots, x_n) = \frac{e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}}{1+e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}}, \text{ (Equation 1)}$$

where $\beta_1, \dots, \beta_n$ denote the beta coefficients of each explanatory variable (i.e., maternal parenting factors) and α is the intercept. It was necessary to estimate the intercept. The marginal probability of being depressed can be written as:

$$\begin{aligned} P(Depressed = Yes) &= \sum_{x_1,\dots,x_n} P(Depressed = Yes, x_1, \dots, x_n) \\ &= \sum_{x_1,\dots,x_n} P(Depressed = Yes \,|x_1, \dots, x_n)\, P(x_1, \dots, x_n) \\ &= \sum_{x_1,\dots,x_n} \frac{e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}}{1+e^{\alpha+\beta_1 x_1+\cdots+\beta_n x_n}} P(x_1, \dots, x_n). \text{ (Equation 2)} \end{aligned}$$

$P(Depressed = Yes)$, is known from the NZ Health Survey 2015/16 as the prevalence of depression in the population (Ministry of Health, 2016). The joint probability among the explanatory variables, $P(x_1, \dots, x_n)$, can be calculated from base population and simulated data. Thus, the intercept, α, of the model can be derived, completing evaluation of the equation (Equation 1).

Our starting sample (of children) was simulated forwards, using the equation above (Equation 1) to calculate the probability of being depressed for each individual. A binomial random variable was generated based on the calculated probability, and a resulting value assigned. This process was repeated with annual updates. The proportion depressed in each year was computed as the mean over 10 runs, sufficient to obtain a stable estimate (with a narrow confidence interval) that changed little with more runs. Results are reported as the proportion depressed, averaged over the ages 15 to 21. We used a two-sample t-test to compare the outcome between base and scenario simulations, across 10 runs from each of the seven age values.

Our simulation model is embedded in an expert decision-support tool, programmed in the R language, which features a graphical user interface (Milne et al., 2017). We have made it accessible on the web for non-technical users with online instructions. The full model includes a range of outcomes, covering childhood and adolescence (ages 2-21). The user will be able to use the tool to repeat the simulation exercises on depression reported in this paper. The tool is a vehicle to practically apply our simulation model to testing scenarios regarding potential interventions, thereby aiding policy development.

Scenario testing

We used the simulated results with no changes made as the 'base' scenario. Note that subsequent changes were considered to be permanent throughout the period studied (ages 15-21). Our scenario testing procedure was as follows:

a) By changing baseline values in the starting sample, we improved single maternal parenting factors in turn to varying degrees (decreasing the high-risk group level by 25%, 50%, and 100% respectively), while keeping other factors constant.
b) We improved a combination of maternal parenting factors to varying degrees as in (1).
c) We compared the effects of improving maternal parenting factors independently, and of their combination, in the whole sample, in the high-risk group (i.e. where any risk factor was present), and broken down by social groups.

Results

The base prevalence of depression averaged 7.4% over the ages from 15 to 21. As risk factors were progressively improved, simulated results showed a concomitant decrease in depression between base case and improvement scenarios (Table 3: see columns under 'All'). For example, eliminating lack of warmth significantly reduced depression from 7.4% to 6.5% (a relative drop of 12.2%), while eliminating harsh discipline significantly reduced depression from 7.4% to 6.7% (dropping 9.5%). However, the strongest impact was achieved by completely eliminating both risk factors, leading to a significant decrease in depression from 7.4% to 5.8% (dropping 21.6%); we deemed this to be the 'best-case' scenario, equivalent to making the high-risk group look like the low-risk group on each risk factor.

Insert Table 3 here

The impact of reductions in risk factor levels is amplified when we focus on the high-risk groups (Table 3: see columns under 'High-risk group'). All scenarios tested yielded significant and substantial decreases in depression, with the best case - both risk factors reduced to zero - showing a 65.0% decrease from 13.1% to 6.3%, approaching the level for the whole sample at 5.8%. In regard to a single risk factor, it appears that modifying maternal lack of warmth was more effective compared to maternal harsh discipline: for example, eliminating the former reduced depression by 45.8%, while eliminating the latter resulted in a lower 32.4% decrease.

The base distribution of depression by social group in the starting sample shows consistent patterns of inequalities (Table 4 – base scenario). The average annual prevalence of depression over the simulated years was higher for youth who were from families of lower socio-economic status, or had parents with less education.

Insert Table 4 here

We then examined the impact of our interventions on different social groups. The extent of improvement for the more disadvantaged groups was greater than for the less disadvantaged groups, with significant differences in outcome for larger reductions in single and, particularly, combined risk factors (Table 4: see improvement scenarios). In the best-case scenario – eliminating both risk factors – the lowest socio-economic status group showed a significant reduction in depression from 11.9% to 8.8% (a drop of 26.1%) compared to the highest socio-economic status group from 5.1% to 4.2% (dropping 17.6%), while depression in the lowest education group fell significantly from 11.3% to 7.7% (dropping 31.9%) compared to a fall from 5.9% to 4.9% (dropping 16.9%) in the highest education group (see Figure 1 for a graphical representation).

Insert Figure 1 here

There was a gradient of effect which improved the outcome for the worst-off but also for the best-off (Table 5). In the best-case scenario, the larger gap in depression prevalence related to parental socio-economic status which closed from 6.8% to 4.6%, while the gap between lowest and highest parental education level closed from 5.4% to 2.8%. In relative terms, the ratio between worst-off and best-off levels of depression was reduced but maintained around double: parental socio-economic status improved from 2.3 to 2.1, and parental education level from 1.9 to 1.6.

Insert Table 5 here

Discussion

This paper presents simulation results from a life-course model testing the effect of maternal parenting drivers – lack of warmth and harsh discipline – on youth depression. We add to the literature in three ways. Firstly, we show what would happen if there were interventions that could improve current settings in levels of risk factors affecting youth depression. Secondly, we contribute to the development of effective policies for tackling issues related to children and youth in NZ by creating a research tool that can be accessed by policy makers. Thirdly, we make use of best estimates taken from international meta-analyses to build our model of the early life course.

Principal Findings and Implications

Research question 1: What is the effect of improving either single or combined *maternal parenting behaviors* on the prevalence of youth depression?

Improving single factors (compared to a combination) had a smaller effect on outcome with maternal lack of warmth being more influential than harsh discipline. The most benefit came from improving a combination of both risk factors. Differences compared to the base were significant where risk factors were completely eliminated, but typically not significant (nor large) otherwise. This implies that substantial improvements to maternal parenting behaviors would be needed to achieve a significant sizeable reduction in depression.

Our findings confirm the importance of fostering a favorable maternal parenting style early in life to promote mental well-being in children and youth (McLeod, Weisz, & Wood, 2007). From a social perspective, the crucial link between risk factors and outcome may be in the development of a strong identity and the capability to form close connections with others (Cruwys, Haslam, Dingle, Haslam, & Jetten, 2014). However, these mechanisms are underpinned by the broader social structure, while the risk factors themselves may be markers of general disadvantage. The pattern in high-risk groups (i.e. those under the negative influence of at least one risk factor) was similar to that for the whole sample, though benefits of intervention were significantly greater in magnitude. This finding indicates that targeting high-risk groups may be the most effective preventive strategy with the best pay-off (Beekman, Smit, Stek, Reynolds, & Cuipers, 2010), but this is fundamentally complicated by structural factors (as described below).

Research question 2: What is the impact of improvements in maternal parenting behaviors on the prevalence of youth depression by *social group*?

Inequalities in the base prevalence of youth depression were evident with higher levels in disadvantaged groups. Scenarios that improved risk factors across the whole sample showed gradients of effect such that benefits to outcome were more pronounced for more disadvantaged groups. However, as benefits accrued to all social groups, progressively reducing risk factors only gradually closed the gap between the worst-off and best-off groups. In the most optimistic scenario, with both risk factors eliminated altogether, depression in the worst-off – though approaching the original baseline value for the whole sample - was still around double that in the best-off. If only the worst-off had been targeted, then the gap between the two groups would have been closed to a greater degree.

In relevance to policy, we were interested in how interventions might impact on health inequalities measured in terms of gradients or gaps (Benach, Malmusi, Yasui, & Martinez, 2013). Much evidence supports material circumstances as determining health inequalities (e.g. Bambra et al., 2010). We consider structural factors as shaping mothers and their parenting behavior that may be instrumental to the development of youth depression. Policy efforts to redress health inequalities must be based on knowing what interventions work for vulnerable social groups at different life stages. Ideally, public

health interventions should produce whole-population health gains as well as close health gaps. Our findings indicate 'proportionate universalism' (Benach, Malmusi, Yasui, & Martinez, 2013) as potentially the most effective intervention strategy. Our findings support family-based interventions in early childhood to prevent the onset of depression. However, so long as disadvantage persists through the life course, this does not tackle the issue of entrenched inequalities since structural factors remain as the primary determinants of health (Viner et al., 2012; Pascoe, Wood, Duffee, & Kuo, 2016).

It is beyond the scope of this paper to propose specific strategies to implement changes in maternal parenting behavior that would result in the reduction of youth depression. We provide a starting point where we demonstrate and quantify the degree of benefit arising from different configurations of improved parenting behavior. Thus, for any given scenario, we address the question: if there was an intervention that could improve parenting behavior by this extent, then what would be the effect on youth depression of implementing that intervention (whatever it may be). Systematic reviews of family-based prevention initiatives (Das et al., 2016; Gladstone, Beardslee, & O'Connor, 2011; Restifo & Bogels, 2009; Yap et al., 2016; Young & Fristad, 2015) indicate promising directions: adopting a life-course approach, enhancing protective factors, targeting both specific and non-specific factors, and targeting high-risk groups.

Strengths and limitations

Given the dearth of evidence, a dynamic microsimulation model as we have constructed is a useful device for addressing policy questions in population health (Smith, Smith, Harper, Manuel, & Mustard, 2014; Rutter, Zaslavsky, & Feuer, 2011; Zucchelli, Jones, & Rice, 2012). The base synthetic cohort derived from the NZ Census and from NZ studies has the distinction of being representative and longitudinal. We took advantage of existing meta-analytic reviews in the literature to obtain best estimates of effect sizes. Furthermore, the simulation model we constructed to integrate these best estimates is well suited to testing policy scenarios. Its core strength lies in the ability to integrate data and to model multiple processes over time within a single system. While a simplification of reality, the model is designed to illustrate utility, to improve understanding, and to indicate likely options for intervention. Results from the broad scenarios tested have been plausible and interpretable, and indicate the range of possible impact of any intervention; in some cases, extreme settings have been

made to amplify changes, drawing attention to them and their effects. The simulation approach also lends itself to better model usability by policy analysts wishing to test their own custom scenarios (e.g. using our online tool).

The chief technical limitation of the simulation approach is its dependence on the availability, quality, and compatibility of input data and parameters (Smith, Smith, Harper, Manuel, & Mustard, 2014). For base prevalence rates of depression, we were reliant on a national survey that defined depression based on receiving a doctor's diagnosis which may under-estimate the true rate as it misses depression for which treatment was not sought (Kessler et al., 2003). Ideally we would estimate prevalence based on national data from diagnostic interviews of adolescents, but such data are not available. We were also reliant on published findings from meta-analytic reviews, whose estimates were considered to be superior to those from individual studies. Estimates from across international studies – though they may better represent underlying dynamics that are arguably universal - may not be fully applicable to the NZ situation particularly considering its unique ethnic mix of the indigenous Māori, European settlers, and migrants from the Asia-Pacific region. With regard to 'harsh discipline', the meta-analytic estimate (OR=1.54) was remarkably similar to that reported in a NZ study (RR=1.5) (Fergusson, Boden, & Horwood, 2008). In addition, we could not test the direct effect of belonging to particular social groups as we did not have such meta-analytic estimates from the literature. A general limitation of using meta-analyses is that the studies included may vary in the extent to which they adjust for confounding and in the list of specific confounders considered. In our case, regarding the positive effect of parental warmth, Yap, Pilkington, Ryan, and Jorm (2014) included studies only if they reported an unadjusted effect size; while regarding the negative effect of physical abuse, Norman et al. (2012) included studies ranging from those with unadjusted associations to those that adjusted for multiple variables. Thus the reported strength of relationships between parenting factors and youth depression may have been attenuated if potential confounders - e.g. parental depression: it may adversely affect the behavior of parent toward child, and/or it may indicate a genetic pre-disposition to depression in the child (Micco et al., 2009) - had been adequately controlled.

Furthermore, in adopting a counterfactual-manipulative interpretation of causality (Campaner et al., 2011), we assumed that pathways to depression would be amenable to policy intervention, and that, in

manipulating one or more specific factors, other initial conditions would remain constant. Our reliance on conditional correlations as input parameters (i.e. meta-analytic estimates) to the simulation model precludes the making of strong causal claims about the effectiveness of the interventions tested.

Future research

The set of relationships between maternal parenting behavior and youth depression needs to be broadened to include other forms of parenting behavior as well as other explanatory variables that impinge on those relationships. This, however, relies on further studies that generate the necessary estimates to inform an expanded model. Prevention efforts must be anchored in better evidence on the risk factors that can be reduced and the protective factors that can be enhanced, within the context of the life course, and scaled at individual, family, and societal levels (Restifo & Bogels, 2009; Hankin, 2012). Further, we need to know more about the intersection between scientific evidence and policy making - how the former can contribute more effectively to the latter - in particular, regarding engagement between modelers and stakeholders, and their co-production of knowledge (Gilbert, Ahrweiler, Barbrook-Johnson, Narasimhan, & Wilkinson, 2018; Lobb & Colditz, 2013).

Conclusion

By synthesizing baseline data from NZ and best estimates from meta-analytic studies, we constructed a simulation model of the early life course, applied to testing population health interventions aimed at reducing the prevalence of youth depression. Findings from counterfactual scenarios suggest the effectiveness of improving maternal parenting factors, with more socially disadvantaged groups deriving greater benefits. Testing scenarios with our simulational life-course model can be gainfully used to inform policy initiatives in tackling the burden of youth depression.

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References

Adolescent Health Research Group. (2013). *The health and wellbeing of New Zealand secondary school students in 2012: Youth'12 prevalence tables*. Auckland: University of Auckland.

Bambra, C., Gibson, M., Sowden, A., Wright, K., Whitehead, M., & Petticrew, M. (2010). Tackling the wider social determinants of health and health inequalities: Evidence from systematic reviews. *Journal of Epidemiology and Community Health*, 64, 248-291. http://dx.doi.org/10.1136/jech.2008.082743

Beardslee, W. R., Gladstone, T. R. G., & O'Connor, E. E. (2012). Developmental risk of depression: Experience matters. *Child and Adolescent Psychiatric Clinics of North America,* 21(2). 261-278. http://dx.doi.org/10.1016/j.chc.2011.12.001

Beekman, A. T. F., Smit, F., Stek, M. L., Reynolds, C. F., & Cuipers, P. C. (2010). Preventing depression in high-risk groups. *Current Opinion in Psychiatry*, 23(1), 8-11. http://dx.doi.org/10.1097/YCO.0b013e328333e17f

Benach, J., Malmusi, D., Yasui, Y., & Martinez, J. M. (2013). A new typology of policies to tackle health inequalities and scenarios of impact based on Rose's population approach. *Journal of Epidemiology and Community Health*, 67, 286-291. http://dx.doi.org/10.1136/jech-2011-200363

Ben-Shlomo, Y., & Kuh, D. (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology*, 31, 285-293. http://dx.doi.org/10.1093/ije/31.2.285

Braveman, P. (2014). What is health equity: And how does a life-course approach take us further toward it? *Maternal and Child Health Journal*, 18(2), 366-372. http://dx.doi.org/10.1007/s10995-013-1226-9

Campaner, R. (2011). Mechanistic causality and counterfactual-manipulative causality: Recent insights from philosophy of science. *Journal of Epidemiology and Community Health*, 65, 1070-1074. http://dx.doi.org/10.1136/jech.2011.134205

Chapman, R., Parkinson, M., & Halligan, S. (2016). How do parent-child interactions predict and maintain depression in childhood and adolescence? A critical review of the literature. *Adolescent Psychiatry*, 6(2), 100-115. http://dx.doi.org/10.2174/2210676606666160822101450

Conger, R. D., Patterson, G. R., & Ge, X. (1995). It takes two to replicate: A mediational model for the impact of parents' stress on adolescent adjustment. *Child Development*, 66, 80–97.

Corna, L. M. (2013). A life course perspective on socioeconomic inequalities in health: A critical review of conceptual frameworks. *Advances in Life Course Research*, 18(2), 150-159. http://dx.doi.org/10.1016/j.alcr.2013.01.002

Cruwys, T., Haslam, S. A., Dingle, G. A., Haslam, C., & Jetten, J. (2014). Depression and social identity: An integrative review. *Personal and Social Psychology Review,* 18(3), 215-238. http://dx.doi.org/10.1177/1088868314523839

Das, J. K., Salam, R. A., Lassi, Z. S., Khan, M. N., Mahmood, W., Patel, V., & Bhutta, Z. A. (2016). Interventions for adolescent mental health: An overview of systematic reviews. *Journal of Adolescent Health,* 59(4), S49-60. http://dx.doi.org/10.1016/j.jadohealth.2016.06.020

Duncan, G. D., & Magnuson, K. (2013). The importance of poverty early in childhood. *Policy Quarterly*, 9(2), 12-17.

Elley, W. B., & Irving, J. C. (1976). Revised socio-economic index for New Zealand. *New Zealand Journal of Educational Studies,* 11, 25-30.

Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2008). Exposure to childhood sexual and physical abuse and adjustment in early adulthood. *Child Abuse and Neglect*, 32(6), 607-619. http://dx.doi.org/10.1016/j.chiabu.2006.12.018

Fram, M. S. (2003). *Managing to parent: Social support, social capital, and parenting practices among welfare-participating mothers with young children*. Institute for Research on Poverty, Discussion Paper No. 1263-03. Madison: University of Wisconsin.

Fuhrmann, D., Knoll, L. J., & Blakemore, S. J. (2015). Adolescence as a sensitive period of brain development. *Trends in Cognitive Sciences,* 19, 558-566. http://dx.doi.org/10.1016/j.tics.2015.07.008

Gilbert, N., Ahrweiler, P., Barbrook-Johnson, P., Narasimhan, K. P., & Wilkinson, H. (2018). Computational modelling of public policy: Reflections on practice. *Journal of Artificial Societies and Simulation*, 21(1), 14. http://dx.doi.org/10.18564/jasss.3669

Gladstone, T. R. G., Beardslee, W. R., & O'Connor, E. E. (2011). The prevention of adolescent depression. *Psychiatric Clinics of North America*, 34(1), 35-52. http://dx.doi.org/10.1016/j.psc.2010.11.015

Hankin, B. L. (2012). Future directions in vulnerability to depression among youth: Integrating risk factors and processes across multiple levels of analysis. *Journal of Clinical Child and Adolescent Psychology*, 41(5), 695-718. http://dx.doi.org/10.1080/15374416.2012.711708

Hoff, E., Laursen, B., & Tardif, T. (2002). Socioeconomic status and parenting. In M. Bornstein (Ed). *Handbook of parenting*. Vol 2, 2nd ed. London: Lawrence Erlbaum Associates.

Hoskins, D. H. (2014). Consequences of parenting on adolescent outcomes. *Societies*, 4, 506-531. http://dx.doi.org/10.3390/soc4030506

Jencks, C., & Mayer, S. (1990). The social consequences of growing up in a poor neighborhood. In L. Lynn L, & M. McGeary (Eds.). *Inner-city poverty in the United States*. Washington DC: National Academy of Sciences Press.

Katz, I., Corlyon, J., La Placa, V., & Hunter, S. (2007). *The relationship between parenting and poverty.* York: Joseph Rowntree Foundation.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Koretz, D., Merikangas, K. R., Rush, A. J., Walters, E. E., & Wang, P. S. (2003). The epidemiology of major depressive disorder: Results from the National Comorbidity Survey Replication (NCS-R). *Journal of American Medical Association*, 289(23), 3095-3105. http://dx.doi.org/10.1001/jama.289.23.3095

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62, 593-602. http://dx.doi.org/10.1001/archpsyc.62.6.593

Kieling, C., Baker-Henningham, H., Belfer, M., Conti, G., Ertem, I., Omigbodun, O., Rohde, L. A., Srinath, S., Ulkuer, N., & Rahman, A. (2011). Child and adolescent mental health worldwide: Evidence for action. *Lancet*, 378, 1515-1525. http://dx.doi.org/10.1016/S0140-6736(11)60827-1

Landry, S. H., Smith, K. E., Swank, P. R., & Guttentag C. (2008). A responsive parenting intervention: The optimal timing across early childhood for impacting maternal behaviors and child outcomes. *Developmental Psychology*, 44(5), 1335-1353. http://dx.doi.org/10.1037/a0013030

Lewis, O. (1966). *La Vida: A Puerto Rican family in the culture of poverty.* San Juan and New York: Random House.

Lobb, R., & Colditz, G. A. (2013). Implementation science and its application to population health. *Annual Review of Public Health*, 34, 235-251. http://dx.doi/10.1146/annurev-publhealth-031912-114444

Maccoby, E. E., & Martin, J.A. (1983). Socialization in the context of the family: Parent-child interaction. In P. H. Mussen (Ed.). *Handbook of child psychology* (pp. 1–103). Vol 4. New York: Wiley.

McLeod, B. D., Weisz, J. R., & Wood, J. J. (2007). Examining the association between parenting and childhood depression: A meta-analysis. *Clinical Psychology Review,* 27, 986-1003. http://dx.doi.org/10.1016/j.cpr.2007.03.001

Meeus, W. (2016). Adolescent psychosocial development: A review of longitudinal models and research. *Developmental Psychology*, 52(12), 1969-1993. http://dx.doi.org/10.1037/dev0000243

Micco, J. A., Henin, A., Mick, E., Kim, S., Hopkins, C. A., Biederman, J., & Hirshfeld-Becker, D. R. (2009). Anxiety and depressive disorders in offspring at high risk for anxiety: A meta-analysis. *Journal of Anxiety Disorders*, 23(8), 1158-1164. http://dx.doi.org/10.1016/j.janxdis.2009.07.021

Milevsky, A., Schlechter, M., Netter, S., & Keehn, D. (2007). Maternal and paternal parenting styles in adolescents: Associations with self-esteem, depression and life-satisfaction. *Journal of Child and Family Studies*, 73, 39–47. http://dx.doi.org/10.1007/s10826-006-9066-5

Milne, B., Chang, K., Shackleton, N., Zhu, T., Liu, C., von Randow, M., Lay-Yee, R., McLay, J., & Davis P. (2017). Shiny application: Knowledge laboratory of the early life-course. Centre of Methods and Policy Application in the Social Sciences, University of Auckland. http://compassnz.shinyapps.io/knowlabshiny/

Milne, B., Lay-Yee, R., McLay, J., von Randow, M., & Davis, P. (2015). Modelling the Early life-course (MELC): A microsimulation model of child development in New Zealand. *International Journal of Microsimulation*, 8(2), 28-60.

Ministry of Health. (2016). *Annual update of key results 2015/16: New Zealand Health Survey.* Wellington: Ministry of Health.

Norman, R. E., Byambaa, M., De, R., Butchart, A., Scott, J., & Vos, T. (2012). The long-term health consequences of child physical abuse, emotional abuse, and neglect: A systematic review and meta-analysis. *PLoS Medicine*, 9(11), e1001349. http://dx.doi.org/10.1371/journal.pmed.1001349

Oakley Browne, M. A., Wells, J. E., & Scott, K. M. (Eds.). (2006). *Te Rau Hinengaro: The New Zealand Mental Health Survey*. Wellington: Ministry of Health.

Ogilvie, D., Hamilton, V., Egan, M., & Petticrew, M. (2005). Systematic reviews of health effects of social interventions: 1. Finding the evidence: How far should you go? *Journal of Epidemiology and Community Health*, 59, 804-808. http://dx.doi.org/10.1136/jech.2005.034181

Pascoe, J., Wood, D., Duffee, J., & Kuo, A. AAP Committee on Psychosocial Aspects of Child and Family Health, Council on Community Pediatrics. (2016). Mediators and adverse effects of child poverty in the United States. *Pediatrics,* 137(4), e20160340. http://dx.doi.org/10.1542/peds.2016-0340

Patten, S. B., Gordon-Brown, L., & Meadows, G. (2010). Simulation studies of age-specific lifetime major depression prevalence. *BMC Psychiatry,* 10, 85. http://dx.doi.org/10.1186/1471-244X-10-85

Reiss, F. (2013). Socioeconomic inequalities and mental health problems in children and adolescents: A systematic review. *Social Science & Medicine*, 90, 24-31. http://dx.doi.org/10.1016/j.socscimed.2013.04.026Dev Psychol. 2008 Sep; 44(5): 1335–1353

Restifo, K., & Bogels, S. (2009). Family processes in the development of youth depression: Translating the evidence to treatment. *Clinical Psychology Review*, 29(4), 294-316. http://dx.doi.org/10.1016/j.cpr.2009.02.005

Rutter, C. M., Zaslavsky, A. M., & Feuer, E. J. (2011). Dynamic microsimulation models for health outcomes: A review. *Medical Decision Making*, 31(1), 10e18. http://dx.doi.org/10.1177/0272989X10369005

Sawyer, S. M., Afifi, R. A., Bearinger, L. H., Blakemore, S. J., Dick, B., Ezeh, A. C., & Patton, G. C. (2012). Adolescence: A foundation for future health. *Lancet*, 379, 1630-1640. http://dx.doi.org/ 10.1016/S0140-6736(12)60072-5

Schwartz, O. S., Sheeber, L. B., Dudgeon, P., & Allen N. B. (2012). Emotion socialization within the family environment and adolescent depression. *Clinical Psychology Review*, 32(6), 447-453. http://dx.doi.org/ 10.1016/j.cpr.2012.05.002

Smith, B. T., Smith, P. M., Harper, S., Manuel, D. G., & Mustard, C. A. (2014). Reducing social inequalities in health: The role of simulation modelling in chronic disease epidemiology to evaluate the impact of population health interventions. *Journal of Epidemiology and Community Health*, 68, 384–389. http://dx.doi.org/10.1136/jech-2013-202756

Statistics New Zealand. (2014). 2006 Census birth cohort SURF. http://www.stats.govt.nz/tools_and_services/university-students/2006-census-birth-cohort.aspx

Totsika, V., & Sylva, K. (2004). The home observation for measurement of the environment revisited. *Child and Adolescent Mental Health,* 9(1), 25-35. http://dx.doi.org/10.1046/j.1475-357X.2003.00073.x

Viner, R. M., Ozer, E. M., Denny, S., Marmot, M., Resnick, M., Fatusi, A., & Currie, C. (2012). Adolescence and the social determinants of health. *Lancet*, 379, 1641-1652. http://dx.doi.org/10.1016/S0140-6736(12)60149-4

World Health Organization. (2017). *Depression and other common mental disorders: Global health estimates*. Geneva: WHO.

Yap, M. B. H., Morgan, A. J., Cairns, K., Jorm, A., Hetrick, S. E., & Merry, S. (2016). Parents in prevention: A meta-analysis of randomized controlled trials of parenting interventions to prevent internalizing problems in children from birth to age 18. *Clinical Psychology Review*, 50, 138-158. http://dx.doi.org/10.1016/j.cpr.2016.10.003

Yap, M. B. H., Pilkington, P. D., Ryan, S. M., & Jorm, A. F. (2014). Parental factors associated with depression and anxiety in young people: A systematic review and meta-analysis. *Journal of Affective Disorders*, 156, 1-23. http://dx.doi.org/10.1016/j.jad.2013.11.007

Young, A. S., & Fristad, M. A. (2015). Family-based interventions for childhood mood disorders. *Child and Adolescent Psychiatric Clinics of North America*, 24(3), 517-534. http://dx.doi.org/10.1016/j.chc.2015.02.008

Zucchelli, E., Jones, A. M., & Rice, N. (2012). The evaluation of health policies through dynamic microsimulation methods. *International Journal of Microsimulation*, 5(1), 2-20.

Predictor	Source	Depression	Ages	Number of studies	Quality [34]
Parental warmth (yes/no)	Yap et al., 2014 [30]	OR = 0.47	2 to 18	18	Medium
Parental physical abuse (yes/no)	Norman et al., 2012 [31]	OR = 1.54	undefined	36	High

Table 1. Effect of maternal parenting factors on depression: Estimates from meta-analytic studies

Data source used to model characteristics	Type	Variable	Percentage
Census 2006	**Demographics**	**Gender**	
		Female	51.0
		Ethnicity	
		NZ European	57.7
		Māori	24.9
		Pacific	8.9
		Asian	8.5
Census 2006	**Social group:** **Parental structural factors (fixed)**	**Parental Education (higher of parents)**	
		No formal qualification	7.6
		Secondary	58.6
		Tertiary	33.8
NZ longitudinal studies (CHDS, DMDHS, PIFS)	**Social group:** **Parental structural factors (fixed)**	**Parental socio-economic status (based on main provider's occupation)**	
		Unskilled, semi-skilled, unemployed	34.7
		Skilled, clerical, technical	41.1
		Professional, managerial	24.3
NZ longitudinal studies (CHDS)	**Risk factor:** **Maternal parenting factor (modifiable)**	**Maternal lack of warmth (at age 5)**	
		High	15.7
		Maternal harsh discipline (at age 5)	
		High	22.2
NZ Health Survey 2015/16	**Outcome**	**Depression (time-variant)**	
		Present (average over 15-21)	7.4
		At age 15	5.4
		At age 16	6.0
		At age 17	6.7
		At age 18	7.6
		At age 19	8.0
		At age 20	8.7
		At age 21	9.3

Table 2. Description of sample (n=5,000): Characteristics of youth (aged 15-21 years)

Scenarios (Ages 15-21)	**Depression All (n=5,000)**		**High-risk group (i.e. risk factor is present at baseline)**	
	% (averaged over ages 15-21)	**% Change (compared to Base)**	**% (averaged over ages 15-21)**	**% Change (compared to Base)**
	n=5,000			
Base [a]	7.4			
Improve single risk factor (modifiable) [b]				
Maternal lack of warmth (actual 15.7%)			n=785 (15.7% of 5000)	
			Base 13.1	
Decrease by 25% of actual (11.8%)	7.2	-2.7%	9.1 *	-30.5%
Decrease by 50% of actual (7.9%)	7.0	-5.4%	8.4 *	-35.9%
Decrease by 100% of actual (0%)	6.5 *	-12.2%	7.1 *	-45.8%
Maternal harsh discipline (actual 22.2%)			n=1,110 (22.2% of 5000)	
			Base 10.8	
Decrease by 25% of actual (16.7%)	7.2	-2.7%	8.3 *	-23.1%
Decrease by 50% of actual (11.1%)	7.1	-4.1%	7.9 *	-26.9%
Decrease by 100% of actual (0%)	6.7 *	-9.5%	7.3 *	-32.4%
Improve combined risk factors (modifiable) [b]			n=208 (4.2% of 5000)	
			Both factors present: Base 18.0	
Decrease all by 25% of actual	6.9	-6.8%	9.5 *	-47.2%
Decrease all by 50% of actual	6.5 *	-12.2%	8.4 *	-53.3%
Decrease all by 100% of actual [c]	5.8 *	-21.6%	6.3 *	-65.0%

a. Base scenario: status quo for the synthetic cohort; b. Improvement defined as decreasing proportion in high-risk group (of risk factor); c. Best-case scenario, i.e. both risk factors reduced to zero; * $p<0.05$ (difference between base and scenario)

Table 3. Youth depression and maternal parenting factors: Base and improvement scenarios by risk level

Scenarios (Ages 15-21)	Parental structural factors (fixed) Socio-economic status (%) Un/semi-skilled	Skilled/ clerical/ technical	Professional/ managerial	Education (%) No formal quals.	Secondary quals.	Tertiary quals.
	Depression: average % (% Change, compared to Base)					
Base [a]	11.9	5.0	5.1	11.3	7.8	5.9
Improve single risk factor (modifiable) [b]						
Maternal lack of warmth						
Decrease by 25% of actual	11.6 (-2.5)	4.9 (-2.0)	4.8 (-5.9)	10.8 (-4.4)	7.5 (-3.8)	5.8 (-1.7)
Decrease by 50% of actual	11.1 (-7.2) *	4.8 (-4.0)	4.7 (-7.8)	10.2 (-9.7) *	7.3 (-6.4)	5.7 (-3.4)
Decrease by 100% of actual	10.1 (-15.1) *	4.6 (-8.0)	4.5 (-11.8) *	9.0 (-20.4) *	6.7 (-14.1) *	5.5 (-6.8) *
Maternal harsh discipline						
Decrease by 25% of actual	11.6 (-2.5)	4.7 (-6.0)	4.8 (-5.9)	10.7 (-5.3)	7.4 (-5.1)	5.8 (-1.7)
Decrease by 50% of actual	11.3 (-5.0)	4.6 (-8.0)	4.7 (-7.8)	10.4 (-8.0)	7.2 (-7.7)	5.7 (-3.4)
Decrease by 100% of actual	10.7 (-10.1) *	4.4 (-12.0) *	4.6 (-9.8) *	9.6 (-15.0) *	6.9 (-11.5) *	5.5 (-6.8) *
Improve combined risk factors (modifiable) [b]						
Decrease all by 25% of actual	11.1 (-7.2)	4.6 (-8.0) *	4.7 (-7.8) *	10.2 (-9.7) *	7.3 (-6.4)	5.6 (-5.1)
Decrease all by 50% of actual	10.3 (-13.4) *	4.4 (-12.0) *	4.6 (-9.8) *	9.4 (-16.8) *	6.8 (-12.8) *	5.4 (-8.5) *
Decrease all by 100% of actual [c]	8.8 (-26.1) *	4.0 (-20.0) *	4.2 (-17.6) *	7.7 (-31.9) *	5.9 (-24.4) *	4.9 (-16.9) *

a. Base scenario: status quo for the synthetic cohort; b. Improvement defined as decreasing proportion in high risk group (of risk factor); c. Best-case scenario, i.e. all risk factors reduced to zero; * $p<0.05$ (difference between base and scenario)

Table 4. Youth depression and maternal parenting factors: Base and improvement scenarios by parental structural factors

Scenarios (Ages 15-21)	Parental structural factors (fixed) Socio-economic status (%) Un/semi-skilled	Skilled/ clerical/ technical	Professional/ managerial	Education (%) No formal quals.	Secondary quals.	Tertiary quals.
	Depression: average %					
Base [a]	11.9%	5.0%	5.1%	11.3%	7.8%	5.9%
Gap between Worst-off and Best-off	11.9 – 5.1 = 6.8			11.3 – 5.9 = 5.4		
Ratio of Worst-off to Best-off	11.9 / 5.1 = 2.3			11.3 / 5.9 = 1.9		
Best-case scenario [b]	8.8%	4.0%	4.2%	7.7%	5.9%	4.9%
Gap between Worst-off and Best-off		8.8 – 4.2 = 4.6		7.7 – 4.9 = 2.8		
Ratio of Worst-off to Best-off	8.8 / 4.2 = 2.1			7.7 / 4.9 = 1.6		

a. Base case scenario: status quo for the synthetic cohort; b. Best-case scenario, i.e. all risk factors reduced to zero.

Table 5. Youth depression and maternal parenting factors: Base and best-case scenarios by parental structural factors

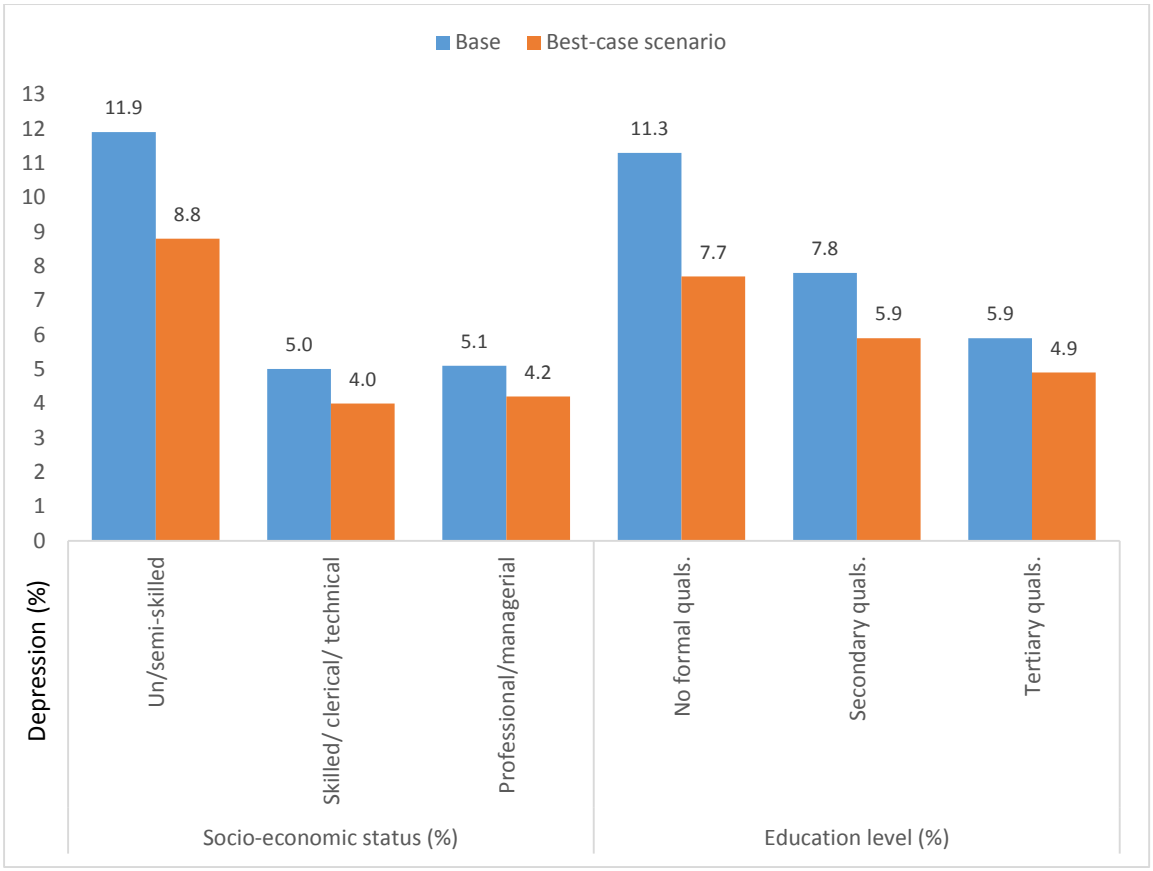

Figure 1. Youth depression: Base and best-case scenarios by parental structural factor