Cost-effectiveness and Return on Investment (ROI) of interventions associated with the Best Start in Life

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Acknowledgements

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Executive summary

In recent years there has been increased understanding of the impact, across the entire life course, of interventions aimed at improving health and wellbeing of the very young. In recognition of this importance, ensuring every child has the Best Start in Life is one of Public Health England's (PHE's) national priorities, as noted in its 2014 priorities document *From evidence into action.*[1]

In October 2015, commissioning responsibility for public health interventions aimed at the 0-5 years population transferred from NHS England to local authorities. To support local authorities in this transition, Public Health England (PHE) established a wide ranging project which aimed to collect and synthesis the economic evidence on commission activities for this age group. This project had two concurrent elements.

One element was a rapid evidence review which looked to summarise the effectiveness and cost-effectiveness evidence on health visitors as delivery agents of the Healthy Child Programme (HCP). The second element was the production of a return on investment (ROI) tool focusing on public health interventions aimed at that same 0-5 years population and/or pregnant women. Construction of the tool was a commissioned project undertaken by Optimity Advisors on behalf of PHE. This report accompanies the ROI tool and provides further details on the underlying data and methodology.

Eleven interventions are included in the tool. These are focused on breastfeeding uptake (two interventions) and preventing or treating postnatal depression (PND) (nine interventions).

The two interventions relating to breast feeding are:

- proactive and reactive calls after hospital discharge for women from more disadvantaged areas to provide breastfeeding support
- enhanced staff contact for all mothers with low birthweight infants

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[1] Public Health England. 2014 [cited 28 July 2017]. *From evidence into action: opportunities to protect and improve the nation's health*. Available from https://www.gov.uk/government/publications/from-evidence-into-action-opportunities-to-protect-and-improve-the-nations-health

The nine interventions relating to PND are:

- midwifery redesigned postnatal care (universal, ie for all mothers)
- peer support for prevention of postpartum depression[2] (targeted at those with, or at risk of, PND)
- group physical therapy exercises (universal)
- cognitive behavioural therapy (CBT)-based intervention (targeted)
- education on preparing for parenting (targeted)
- interpersonal psychotherapy (IPT)-based intervention (targeted)
- calcium prescription (universal)
- booklet on postnatal depression (universal)
- early contact with care provider (universal)

These interventions were selected based on a rapid review of the economic evidence. Included interventions represent those with the most robust data in a form useful for building a tool, rather than necessarily the most effective or cost-effective interventions for this population. Interventions provided with ROI metrics through tools produced by the National Institute for Health and Care Excellence (NICE) (currently available in beta versions) were not considered for inclusion. In this way the NICE ROI tools and PHE's Best Start in Life ROI tool are complementary and should be reviewed in tandem.

Default results

A summary of the default results, comparing the interventions to usual care, are as follows:

Of the two breastfeeding interventions, one (enhanced staff contact for underweight new-borns) is dominant, and the other (proactive and reactive calls) is cost-effective, with a very low incremental cost effectiveness ratio (ICER) (£1,939 per quality adjusted life year (QALY)). An intervention is described as dominant if it is estimated to be both cost saving and deliver positive health gains. An ICER is the difference in the change in mean costs in the population of interest divided by the difference in the change in mean outcomes in the population of interest. When compared to the NICE threshold for cost-effectiveness of £20,000-£30,000 per QALY, the ICER suggests, in a simplistic, yet effective way, that the intervention is a good use of resources. It is also close to being both cost saving and health improving as the net cost is only just greater than £1. Given there are some benefits for these interventions that were not possible to measure, it is expected that this analysis slightly underestimates the benefits and potential cost savings.

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[2] The source evidence refers specifically to postpartum depression. For simplicity, this intervention is referred to as a PND intervention; however, when referencing the full name of the intervention, the original source terminology is maintained.

The first three PND interventions; midwifery redesigned postnatal care, peer support intervention for prevention of postpartum depression and group physical therapy exercises, are all estimated to dominant over usual care. These interventions are labelled as "full", both in this report and the ROI tool, as the evidence sources had sufficient data to estimate a relatively complete picture of their impact.

For the final six postnatal depression interventions default ICERs range from £147 to £41,258, suggesting some are cost-effective, compared to the NICE threshold range, but others not. However, these estimates likely overestimate the cost and under estimate the QALY gains significantly as explained in the paragraph below. Because of the limitations of the available evidence on the full impact of these interventions, they are labelled "basic" in this report and the ROI tool.

For the basic PND interventions, the overestimation of costs, and underestimation of QALY gains was because it was not possible to link the reported health gains to the mother to number of cases of PND avoided. Thus the model was unable to incorporate cost savings and health benefits beyond those accruing to the mother in the first year, or any health gains for the child. The ICER results should be viewed in that context.

Break-even analysis was conducted on these basic interventions to try and understand how many cases averted would be needed in order them to be cost saving and health improving. These numbers can then be compared to the number of cases averted predicted from the full PND interventions. The results, for a hypothetical treatment cohort of 10,000, are shown below in Table 1.

Table 1 – Required number of cases averted necessary for basic PND interventions to be dominant compared with equivalent estimated values from full PND interventions

	"Basic" PND interventions		"Full" PND interventions	
	Intervention	**Required cases averted (per 10,000 treated)**	**Intervention**	**Cases averted (per 10,000)**
Targeted interventions	CBT-based intervention,	119	Peer support intervention for prevention of postpartum depression	638
	Education on preparing for parenting,	320		
	IPT-based intervention	596		
Universal interventions	Calcium prescription	95	Midwifery redesigned postnatal care	657
	Booklet on PND	1	and	and
	Early contact with care provider	49	Group physical therapy exercises	650

The smaller the number of cases that need to be averted per 10,000 people treated, the more likely the basic intervention is to be dominant. As shown above, the basic interventions all have lower number of cases to be averted than the full PND interventions. Given the full PND interventions are all dominant over usual care, such results may also indicate that the basic interventions would be too, if evidence supported inclusion of wider costs and benefits in the analysis.

More generally, there is great difficulty in comparing the cost-effectiveness metrics of the included interventions because of the differing selection of costs and benefits included. A more comprehensive summary, providing details of what is and is not included in the analysis, is presented in the tables below:

Table 2 – summary of economic analysis: Hoddinott et al (2012)

Paper	Intervention	Net benefit for mother-child dyad	QALY gains for mother-child dyad	ICER
Hoddinott et al., 2012	Breastfeeding uptake – Proactive and reactive call (targeted in deprived areas)	-£1.04	0.00053	£1,939
Included in the analysis:		- Cost of the intervention - Additional breastfeeding uptake - Cost savings and QALY gains achieved for both child (one year only, although QALY losses from early mortality are calculated for all life years lost) and mother (lifetime, from reduced breast cancer risk only) - Health benefits due to reduced child mortality from gastrointestinal illnesses, lower respiratory tract infection, acute otitis media and necrotising enterocolitis (NEC); and reduced cases of breast cancer for the mother		
Not included in the analysis:		- Longer-term child benefits - Other potential benefits to the mother		

Table 3 – summary of economic analysis: Renfrew, (2009)

Paper	Intervention	Net benefit child		QALY gains for child		ICER
Renfrew, 2009	Breastfeeding uptake and child outcomes – Enhanced staff contact for underweight newborns	500-999g	£563	500-999g	0.25	Dominant for all cases
		1000-1749g	£271	1000-1749g	0.05	
		1750-2500g	£44	1750-2500g	0.01	
Included in the analysis:		- Cost of the intervention - Additional breastfeeding uptake - Cost savings and QALY gains achieved for the child (lifetime) - Health benefits due to reduced child morbidity and mortality from sepsis and necrotising enterocolitis (NEC)				
Not included in the analysis:		- Benefits to the mother - Breakdown of the child benefits into number of cases of specific conditions avoided				

Table 4 – summary of economic analysis: Morrell, (2016) – Full PND interventions

Paper	Intervention	Net benefit for mother-child dyad	QALY gains for mother-child dyad	ICER
Morrell, 2016 (1)	Midwifery redesigned postnatal care, universal intervention (Macarthur et al., 2002)	£455	0.127	Dominant
	Peer Support Intervention for prevention of postpartum depression, targeted intervention (Barnes et al., 2009)	£109	0.132	Dominant
	Group physical therapy exercises, universal intervention (Norman et al., 2010)	£491	0.126	Dominant
Included in the analysis:		- Cost of the intervention - Cases of postnatal depression averted due to the intervention - Cost savings - QALY gains achieved for both child (lifetime) and mother (up to 10 years after birth) - Health and other public sector benefits due to reduced depression and suicide		

	in the mother and reduced infant death, emotional problems, conduct problems, special educational needs, and from leaving school without qualifications[3]
Not included in the analysis:	• No specific gaps although breakdown could be more granular

Table 6 – summary of economic analysis: Morrell, (2016) – Basic PND interventions

Paper	Intervention	Net benefit for mother only	QALY gains for mother only	ICER
Morrell, 2016 (2)	CBT-based intervention, targeted intervention (Barnes, 2009)	-£103	0.0025	£41,258
	Education on preparing for parenting, targeted intervention (Sen, 2006, Zlotnik et al., 2001)	-£277	0.0158	£17,551
	IPT-based intervention, targeted intervention (Chabrol et al., 2003)	-£516	0.0147	£35,083
	Calcium prescription, universal intervention (Harrison-Hohner et al., 2001)	-£82.27	0.0086	£9,566
	Booklet on PND, universal intervention (Sealy et al., 2009)	-£1.12	0.0076	£147
	Early contact with care provider, universal intervention (Gunn et al., 1998)	-£42.72	0.0058	£7,365
Included in the analysis:	• Cost of the intervention • QALY gains to the mother (one year) • Health benefits from reduced levels of depression in mothers			
Not included in the analysis:	• Cost savings • Child benefits • Longer-term mother benefits • Raw data, eg number of cases			

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[3] Benefits on pre-term birth were excluded: the paper used for this analysis covered perinatal rather than just postnatal depression and it was deemed this element related to depression before birth. (It was unclear to what extent other benefits would change if the focus was solely on postnatal depression.) Source for the analysis: Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

- Please note that the mother-child dyad refers to the combined net-benefit and QALY gains for both mother and child.
- Net benefit represents cost savings that result from the intervention less intervention cost.
- All costs and benefits are measured versus the comparator from the original papers, normally usual care.
- Conducting the analysis included sourcing information from beyond the papers listed above to build upon the original results.
- The discount rate applied to the outcomes of the intervention drawn from Renfrew is 3.5%, the rate applied to the analysis.
- The default discount rate applied to the outcomes of the intervention drawn from Hoddinott is 1.5%. This rate can be adjusted by the user.
- The discount rate applied for the interventions for Morell (1) is 3.5%. This is the rate applied to the LSE et. al. (2014) calculations, of which the outcomes of these interventions are drawn.
- The discount rate applied for the interventions for Morell (2) is 0%, as no discounting was applied to the analysis with which these interventions are drawn.
- Where relevant the primary reference for the intervention study is provided in the intervention column.

Conclusions

The aim of the ROI tool is to provide a useful resource for service planners within local authorities and CCGs to help prioritise maternal and child services (0-5 years). It does this by providing cost-effectiveness metrics, and some qualitative information, for a series of interventions related to breastfeeding and PND.

Unfortunately, due to limitations in the available evidence, it was not possible to include a broader range of interventions associated with the Best Start in Life (0-5 years). It is important to note that although breastfeeding and PND are the two areas included in the model, it does not mean that these are necessarily the most cost-effective areas in which to invest. As such, a key recommendation is that more research is directed towards economic analyses of interventions associated with the Best Start in Life (0-5 years).

It is also recommended that future economic research looks to incorporate results in natural units alongside the standard cost-effectiveness metrics. This will facilitate more intuitive comprehension and an understanding of what QALY gains and cost savings are driven by, and to help with any future research link outcome studies to intervention studies.

Of the two breastfeeding studies, one was dominant (enhanced staff contact for underweight newborns) and one was very cost-effective (proactive and reactive calls)

with a small additional cost and an ICER under £2,000. For PND, the full interventions, which were able to be linked to longer-term outcomes, were all dominant. For the basic PND interventions, where it wasn't possible to link effectiveness to longer-term outcomes, break-even analysis also suggests these all could dominant if a fuller evaluation was possible. Hence, there is a strong case to be made for investment in these interventions.

1. Introduction

In recent years there has been increased understanding of the impact, on both outcomes and costs across the entire life course, of public health interventions aimed at the very young.

Eighty per cent of brain cell development takes place by age three, and early attachment and good maternal mental health impact on emotional, behavioural and intellectual development. There is also evidence that "socially disadvantaged children are more likely to have speech, language and communication difficulties than their peers".[4] In turn poor communication issues have been linked to worse educational attainment, peer relationships, emotional problems and impaired social behaviour.

Poor attainment in the early years indicators have been associated with an increased risk of premature death and major chronic diseases in children[5,6,7,8] and ongoing into adulthood.[9,10,11] These include developmental problems, mental and behavioural disorders, as well as an increase in injuries, falls and traffic accidents that require hospital admission or result in death.

In recognition of these issues, ensuring every child has the Best Start in Life is one of Public Health England's (PHE's) national priorities, as noted in its 2014 priorities document *From evidence into action.*[12]

In October 2015 commissioning responsibility for public health interventions aimed at the 0-5 years population transferred from NHS England to local authorities. To support local authorities in this transition, Public Health England (PHE) established a wide

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[4] Ibid

[5] Hack, M., Horbar, J. D., Malloy, M. H., Wright, L., Tyson, J. E., &and Wright, E. (1991). Very low birth weight outcomes of the National Institute of Child Health and Human Development neonatal network. Pediatrics, 87(5), 587-597.

[6] Cnattingius, S. (2004). The epidemiology of smoking during pregnancy: smoking prevalence, maternal characteristics, and pregnancy outcomes. Nicotine & Tobacco Research, 6(Suppl 2), S125-S140.

[7] Reilly, J. J., Armstrong, J., Dorosty, A. R., Emmett, P. M., Ness, A., Rogers, I., ... & Sherriff, A. (2005). Early life risk factors for obesity in childhood: cohort study. Bmj, 330(7504), 1357.

[8] Campbell, F. A., Ramey, C. T., Pungello, E., Sparling, J., & Miller-Johnson, S. (2002). Early childhood education: Young adult outcomes from the Abecedarian Project. Applied Developmental Science, 6(1), 42-57.

[9] Hack, M., Flannery, D. J., Schluchter, M., Cartar, L., Borawski, E., & Klein, N. (2002). Outcomes in young adulthood for very-low-birth-weight infants. New England Journal of Medicine, 346(3), 149-157.

[10] Brennan, P. A., Grekin, E. R., & Mednick, S. A. (1999). Maternal smoking during pregnancy and adult male criminal outcomes. Archives of general psychiatry, 56(3), 215-219.

[11] Boney, C. M., Verma, A., Tucker, R., & Vohr, B. R. (2005). Metabolic syndrome in childhood: association with birth weight, maternal obesity, and gestational diabetes mellitus. Pediatrics, 115(3), e290-e296.

[12] Public Health England. 2014 [cited 28 July 2017]. *From evidence into action: opportunities to protect and improve the nation's health*. Available from https://www.gov.uk/government/publications/from-evidence-into-action-opportunities-to-protect-and-improve-the-nations-health

ranging project to collect and synthesis the economic evidence on commission activities for this age group. This project had two concurrent elements.

One element was a rapid evidence review which looked to summarise the effectiveness and cost-effectiveness evidence on health visitors as delivery agents of the Healthy Child Programme (HCP). The second element was the production of a return on investment (ROI) tool focusing on public health interventions aimed at that same 0-5 years population and/or pregnant women.

The tool has been designed to fill in some of the gaps in the evidence base surrounding interventions aimed at the 0-5 years population, and/or pregnant women, and support cost-effective public health commissioning. It does this by allowing the user to see economic outcomes for included interventions within customisable scenarios. These interventions were selected based on a rapid review of the economic evidence. Included interventions represent those with the most robust data in a form useful for building a tool, rather than necessarily the most effective or cost-effective interventions for this population. Further, the tool was constructed with the intention of complementing the National Institute for Health and Care Excellence (NICE) ROI tools; the Children and Young People (CYP) ROI tool and Social and Emotional Wellbeing over the life course (SEW) ROI tool. As such, interventions provide with ROI metrics from either of those NICE tools were excluded from the PHE Best Start in Life tool (see **Appendices Appendix** A:
Interventions with ROI metrics from NICE's Children and Young People and Pregnant Woman (CYP) and Social and Emotional Wellbeing (SEW) ROI tools
 for full list of interventions that have previously been adequately covered by NICE's work and so are outside of scope for the ROI tool). Both of these NICE developed tools are available on the organisations website in beta form. These resources should be considered in tandem to the PHE developed Best Start in Life tool.

Construction of the tool was a commissioned project undertaken by Optimity Advisors on behalf of PHE. This report accompanies the ROI tool and provides further details on the underlying data and methodology.

The rest of the report is structured as follows; section two describes the methodology and criteria used to conduct the evidence review, and a description of the shortlisting of interventions and data extraction process.

Section three describes the findings from the evidence review, and a summary of the data extracted and findings from each of the reports from which the selected interventions are drawn.

Section four describes in detail the economic analyses conducted in order to convert findings from the review into useful parameters for use in the ROI tool.

Section five provides a step-by-step description of tool inputs and outputs.

Finally, section six presents the conclusions, where key findings, gaps in the evidence base surrounding interventions aimed at the best start in life (0-5 years), and recommendations for future research, are presented.

2. Methods

Project aims

The aim of the ROI tool development was to collate existing evidence on the cost-effectiveness and ROI of interventions aimed at 0-5 year olds and/or pregnant women. The development of the ROI tool consisted of an initial feasibility study (Phase I) to examine the extent to which suitable evidence exists to enable ROI metrics to be generated, followed by tool development itself (Phase II).

Project approach

The approach adopted in Phase I of the project was the following:

- a rapid evidence review to identify evidence on the cost-effectiveness of interventions aimed at improving outcomes for children aged 0-5 years and/or pregnant women, and
- a feasibility study exploring the extent to which these interventions could be included in an ROI tool

As with all of Optimity Advisors' evidence reviews, a systematic approach was adopted to identify, assess and synthesise relevant cost-effectiveness data and outcomes. This ensured that the findings are comprehensive and reliable, and hence, that the ROI tool development in Phase II would be based on an accurate understanding of the evidence.

Throughout the project engagement, Optimity Advisors met regularly with a Steering Group consisting of project and topic experts, from within PHE and other stakeholder organisations, and consulted with external subject matter experts. In addition, a user-group, of local authority representatives, was also utilised to test the usability, reliability and relevance of the tool for its target user group.

Evidence review methodology

The search for evidence took three forms:

- A formal literature search of databases of published literature, using a specific search strategy;
- A search for grey literature, through examining key websites and Google searches;

- A call for evidence issued to the members of the project Steering Group and other stakeholders, and published online.

The search for evidence focused specifically around economic studies with a target population of children aged from 0-5 years old and/or pregnant women.

The literature search used to identify evidence for the ROI tool was conducted separate to that used to inform the other overarching project element, the health visitors report. However, abstracts identified through the ROI evidence search were additionally sifted for inclusion in the health visitors report. Studies could have been included in one of, or both the ROI tool and the health visitor report.

The ROI tool search strategy was agreed with the project Steering Group, and is provided in Appendix B: Search Strategy and database search results
. An abridged version of the search strategy is provided below in Figure 1.

The final search terms were developed and the search itself was conducted by the PHE Knowledge & Library Services across the following databases: Medline, Embase, AMED, CINAHL, HMIC, Cochrane Library, DoPHER, TRoPHI, BNI and EconLit.

Figure 1. Abridged search strategy

Search strategy:

- Terms for pregnancy, newborns, infants, children and parents

and

- Terms for public health, health visitors, breastfeeding, nutrition, physical activity, oral health, behaviour, smoking, alcohol, drug use, immunisation, mental health, home safety, accident preventions

or

- Terms for public health nurse, home visiting, family health nurse, child health nurse

and

- Terms for cost-effectiveness, cost-benefit analysis, return on investment, cost savings

Grey literature was retrieved using search terms such as "Economic evidence child 0-5 interventions", and also via specific websites, such as those of the Department for Education, National Society for the Prevention of Cruelty to Children (NSPCC), NICE, and the Early Intervention Foundation. Due to the wide scope of the search, only contextual information, rather than specific interventions, was retrieved.

The call for evidence was issued in December 2016, and literature received before the mid-January deadline was included.

Intervention selection and shortlisting

All abstracts from the search were screened and assessed for inclusion or exclusion using specific criteria. Studies were included if they:

- were published in 2009 or later
- related to children aged 0-5 years and/or pregnant women
- were conducted in the UK, Ireland, the USA, Canada, Australia or New Zealand
- provided quantitative evidence of cost-effectiveness (or similar economic findings) for an intervention

- An example of the template used to screen abstracts is provided in Appendix C: Inclusion and exclusion criteria

. The full texts from the included abstracts and call for evidence were retrieved and screened using the same criteria as listed above. Data was first extracted from the included full texts to classify the interventions into topic areas and perform an initial feasibility to model analysis. In particular, the following information was extracted for each of the included interventions:

- reference (unique identifier)
- sStudy design (eg systematic review, cost-benefit, cost-effectiveness, effectiveness etc.)
- country
- setting (eg home visiting, secondary care setting etc.)
- population and participants characteristics
- intervention topic (as described above)
- intervention type (eg Clinical intervention comparing two rotavirus vaccinations)
- intervention name
- intervention description
- comparator
- can the intervention be costed?
- outcomes reported (eg PND, uptake of breastfeeding etc.)
- outcome metrics (eg Edinburgh Postnatal Depression Scale (EPDS) scores, percentage of women breastfeeding, quality adjusted life year (QALYs), etc.)

For the initial feasibility to model analysis, we looked at three key criteria:

- Are there any QALYs reported?
- Are there any cost savings or healthcare utilisation outcomes reported?
- Are there any overall cost-effectiveness measures reported?

A Red-Amber-Green indication was given to each study, which later helped prioritise the interventions for modelling.

The interventions were then shortlisted by intervention topic with PHE and the Steering Group. The criteria of this shortlisting exercise included the following:

- Has a tool been previously developed, or commissioned for development, for the specific intervention topic?
- Is the intervention topic a priority area for PHE?
- Is there sufficient information or evidence available?
- Is it feasible to model the specific intervention topic from the evidence collected?
- Is the population and/or the setting relevant?

As a result of this shortlisting process, only the topic areas of breastfeeding or post-natal depression were (PND) included in the ROI tool. A list of other considered topics, along with a brief description of the reason for their exclusion from the tool is provided in Table 1.

Table 1 – Intervention topic areas – Included, shortlisted or excluded

Topic area (number of papers identified)	Included, shortlisted or excluded
Additional child education (2)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Breastfeeding (4)	Shortlisted and included: 2 papers included in the tool
Child behaviour management (7)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Child language development (1)	Intervention area not shortlisted: One report containing no economic data
Home safety education and injury prevention (4)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Immunisation (15)	Shortlisted but excluded: One paper initially shortlisted after examination of results but final decision that it was unlikely to be generalisable to a UK context or to have a significant impact
Maternal mental health (6)	Shortlisted and included: 1 review included in the tool
Maternal physical health (5)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Multiple child development and	Shortlisted but excluded:

Topic area (number of papers identified)	Included, shortlisted or excluded
nutritional improvement (1)	Lack of robust economic data to model reported interventions
Nutrition (2)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Obesity (13)	Shortlisted but excluded: Several interventions not cost-effective and where proven to be cost-effective, outside of target population
Oral health (8)	Intervention area not shortlisted: Covered in PHE Oral health tool
Parental Mental Health (1)	Shortlisted but excluded: High level of uncertainty around the effectiveness of the intervention and no significant difference in outcomes between control and intervention groups.
Parenting skills (8)	Shortlisted but excluded: Several reports showed no statistically significant difference between intervention and control groups. In addition, there was difficulty linking outcomes of the studies to quality adjusted life year (QALYs).
Parenting skills and child education (2)	Shortlisted but excluded: Very context specific to target US population intervention with few details on cost of intervention
Physical activity (2)	Intervention area not shortlisted: Lack of robust economic data to model reported interventions
Substance abuse (6)	Intervention area not shortlisted: All papers centred on smoking cessation in pregnancy, which is covered in NICE ROI tool.

The decision to exclude other topic areas, which had been identified in the literature, was primarily due to a lack of useful data available. It is important to note that although breastfeeding and PND are the two areas included in the model, it does not mean that these are necessarily the most cost-effective areas in which to invest. A lack of robust, readily available data means such a statement cannot be easily corroborated. Similarly, areas excluded during the development of the tool are not necessarily any less cost-effective; rather, the evidence available was not sufficient to conduct an economic assessment without significant extra parameter searching and analysis.

More comprehensive, intervention level information on reasons for inclusion or exclusion from the ROI tool is provided in Appendix D:

Summary of interventions / topics – Included / Excluded for modelling

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The shortlisted interventions were assessed for quality, using quality appraisal checklists recommended by NICE.[13] For single, quantitative studies, the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies was used;[14] for systematic reviews, the AMSTAR 2 tool was used,[15] and for economic studies (and reviews with additional economic analysis), NICE's own checklist was used. Detailed data was then extracted from the interventions for both single studies and systematic review papers,and fed through to further analysis for inclusion in the model.

The following additional data were extracted from the shortlisted interventions:

- method of analysis (observational longitudinal analysis, RCT, etc.)
- first order outcomes
- secondary outcomes
- limitations
- additional comments
- study quality
- intervention costs
- comparator costs
- all outcome probabilities
- outcome cost savings
- outcome utility/QALY gains
- perspectives used (healthcare providers, social etc.)
- time horizon used
- discount rate
- feasibility of modelling (poor, moderate, strong)
- extra parameters needed

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[13] National Institute for Health and Care Excellence. 2015 [cited 19 Jan 2018]. Developing NICE guidelines: the manual appendix H. Available from https://www.nice.org.uk/process/pmg20/resources/developing-nice-guidelines-the-manual-appendix-h-pdf-2549711485

[14] Effective Public Health Practice Project. Quality Assessment Tool for Quantitative Studies. [Cited 19 Jan 2018.] Available from http://www.ephpp.ca/tools.html

[15] AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. [Cited 19 Jan 2018.] Available from http://www.amstar.ca/docs/AMSTAR-2.pdf

The overall process flow of the intervention selection can be summarised in the diagram below.

Figure 2. Schematic diagram of evidence collection and intervention inclusion to ROI tool
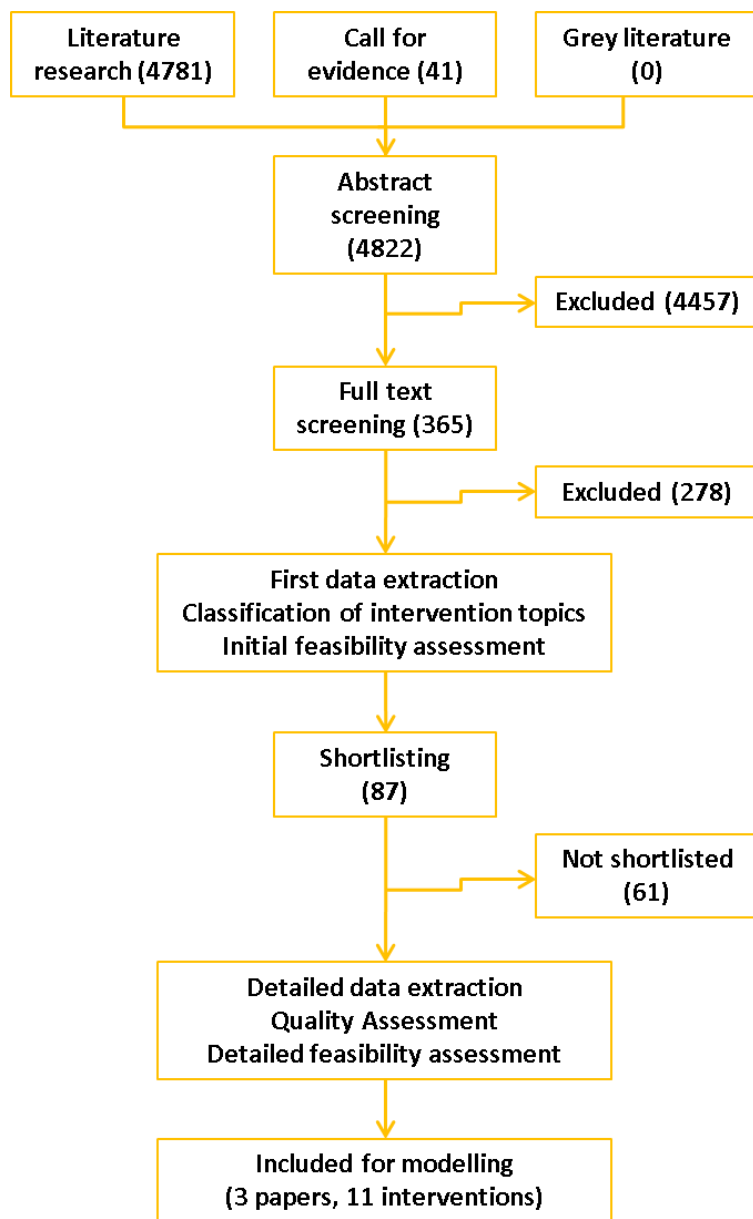
Analysis methodology

The framework used to construct the ROI models for each intervention can be summarised in the simplified diagram below:

Figure 3. ROI tool methodology

This approach examines the impact of the intervention on the first order outcome (eg breastfeeding, PND), the associated costs and QALYs of that outcome, and the consequent impact on second order outcomes, such as child health.
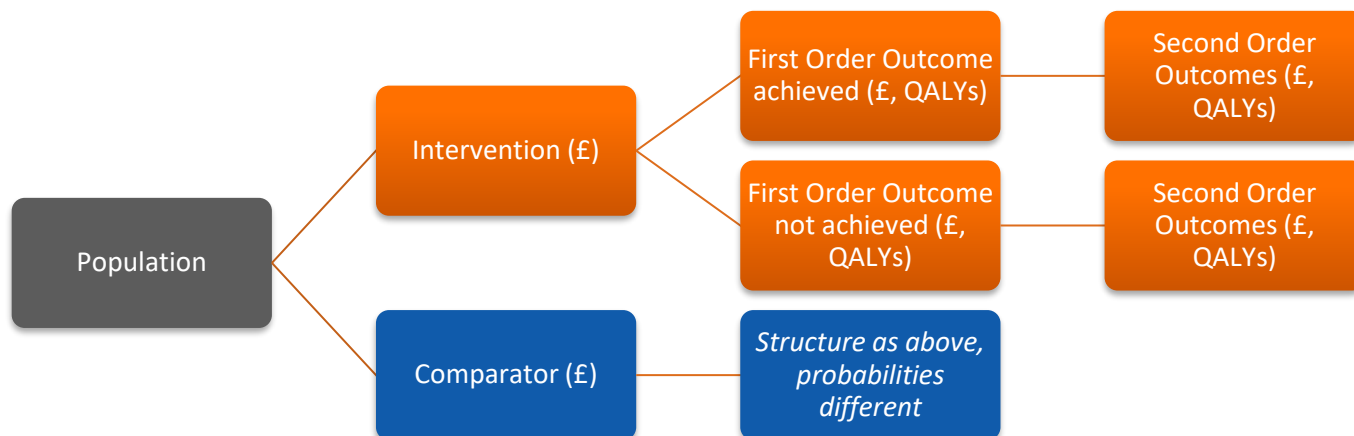
This can then be aggregated to understand the incremental cost of the intervention (over and above the comparator), the consequent cost savings from the intervention, and the clinical outcomes (ideally in QALY gains/losses) of the first and second order outcomes. Where these data were available, it was extracted and overall figures (Incremental Cost-Effectiveness Ratio (ICER), and net benefit) were calculated as in the formulae below:

$$ICER = \frac{net\ benefit}{QALYs\ gained}$$

Where:

$$net\ benefit = cost\ savings - intervention\ costs$$

Some papers reported ICERs and net benefit directly, and this was also extracted.

Cost savings include any incremental savings that stem from the intervention such as reduced hospitalisations or other healthcare costs. Costs include any incremental costs, such as direct intervention costs or other costs accrued due to the intervention such as through employing support workers to deliver the intervention.

It is important here to note that in several cases, the data extracted from the research papers were not complete and gaps in the evidence existed. In addition, in a few cases the data extracted from the included studies had to be converted into useful data for modelling. For example, a study may have reported effectiveness by using metrics other

than QALYs gained/lost or the cost savings may have been reported only for the mother and not for the child. These issues were addressed, where possible, by performing additional parameter searches and evidence collection. These parameters were either collected by further study research or were indicated by the Steering Group or the subject matter experts involved in the project.

Analysis and tool

The developed tool follows the high-level methodology, as shown below, whereby users see the tool inputs and outputs. A background economic model (indicated in orange) calculates the findings:

Figure 4. High-level methodology of ROI tool
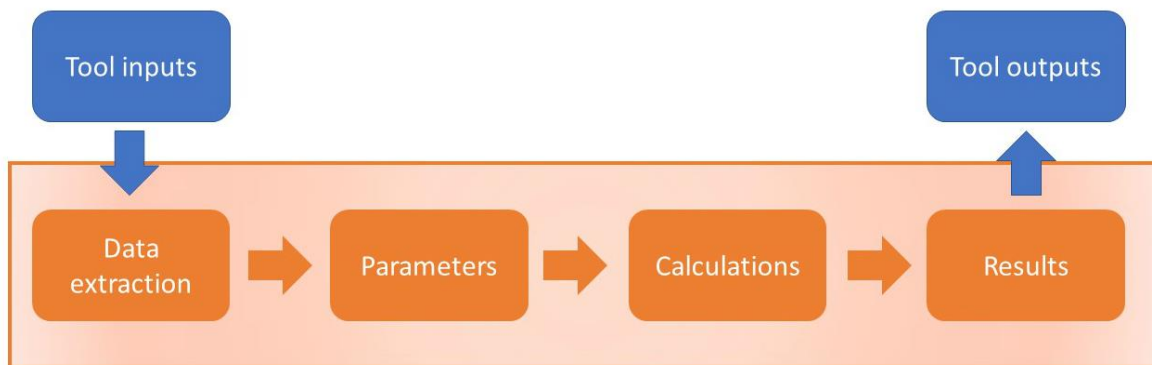
In order to make the tool dynamic and relevant to the current health and social care setting, additional research was performed to identify key prevalence rates to be used in the model, such as the average UK breastfeeding proportions, incidence of breast cancer, UK incidence prevalence of postnatal depression and other factors. (Sources are provided in Section 4.1 on tool inputs.)

The tool then uses these inputs and the fixed data from the data extraction to calculate overall costs, cost savings, net benefits, QALY gains, and ICERs. The calculation may also include intermediate steps such as the calculation of the cases of PND averted or new cases of exclusive breastfeeding (first or second order outcomes). These intermediate calculations are used to quantify the clinical outcomes and are used in subsequent calculations to monetise costs and QALYs gained/lost.

The tool presents the results in several forms:

- per person results – in some cases combined as mother + child outcomes
- per population/geography
- per group of interventions – when more than one intervention has been selected

It is important to note that the aim of the economic tool is to provide users with a simple data analytical tool that can help inform commissioning and delivery decision-making regarding interventions aimed at young children aged 0-5, and/or pregnant women. It does not provide a definitive answer to commissioners as to where to allocate resources, rather it helps inform commissioners and other interested parties as to the impact of the likely consequences associated with alternative commissioning decisions.

Findings from evidence review

Details on the final list of shortlisted studies, covering breast feeding and PND are summarised in the table below.

Table 2 - summary of selected interventions

Intervention type	Paper	Study type	Country	Description	Quality Assessment
Breastfeeding	Hoddinott, 2012	Randomised Control Trial	UK	Proactive and reactive call after hospital discharge for women in more disadvantaged areas to provide breastfeeding support and increase breastfeeding uptake. Comparator: reactive call only	Study Quality: Moderate (EPHPP scale: Strong/Moderate/Weak)
Breastfeeding	Renfrew, 2009	Systematic Review, Economic analysis, Modelling	Various (done for the UK)	Enhanced staff contact (support with breastfeeding and milk expression) for all mothers with low birth weight infants in neonatal units.	Applicability: directly applicable Limitations: minor limitations (NICE scales: directly/partially/not applicable, and minor/potentially serious/very serious limitations)

				Comparator: normal staff contact	
Postnatal depression (PND)	Morrell, 2016	Systematic Review, Economic Analysis	Various (done for the UK)	Multi-component interventions targeted at all women, or at women with, or at risk of, postnatal depression (multiple interventions) Comparator: usual care	Applicability: directly applicable Limitations: minor limitations (NICE scales: directly/partially/not applicable, and minor/potentially serious/very serious limitations)

With regards quality assessment, the AMSTAR 2 tool, a tool for critical appraisal of systematic reviews of healthcare interventions, was also applied to assess the quality of the Renfrew (2009) and the Morrell (2016) reviews. The tool is not designed to give an overall score so that flaws in critical domains that may weaken the confidence placed in the review are not overlooked. Key focuses of the tool include assessment on whether there was a comprehensive literature search, an appropriate assessment of the risk of bias, and whether an appropriate statistical method was used for meta-analysis. Both the Renfrew (2009) and the Morrell (2016) reviews scored strongly on these three criteria after the evaluation using the AMSTAR 2 tool.

From the Morrell (2016) review, all interventions were included with the exception of those that were either: not effective, had a reported ICER of greater than £60,000,[16] or where the methodology used to cost the intervention was deemed uncertain.[17]

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[16] This is consistent with the willingness to pay value used for QALYs by the NHS and PHE. See for example: Department of Health: see. 2011 [cited 3 Aug 2017]. Impact Assessment. Improving Outcomes; A Strategy for Cancer. Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216003/dh_120108.pdfhttps://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213768/dh_123505.pdf

[17] This referred to the universal Person-Centered Approach (PCA) and CBT based interventions taken from Morrell (2009) in the review

As a result, the following PND interventions were extracted:

- midwifery redesigned postnatal care (universal, ie for all mothers)
- peer support for prevention of postpartum depression[18] (targeted at those with, or at risk of, PND)
- group physical therapy exercises (universal)
- cognitive behavioural therapy (CBT)-based intervention (targeted)
- education on preparing for parenting (targeted)
- interpersonal psychotherapy (IPT)-based intervention (targeted)
- calcium prescription (universal)
- booklet on postnatal depression (universal)
- early contact with care provider (universal)

A full extraction table of included studies can be found in Appendix D: Summary of interventions / topics – Included / Excluded for modelling

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[18] The source evidence refers specifically to postpartum depression. For simplicity, this intervention is referred to as a PND intervention; however, when referencing the full name of the intervention, the original source terminology is maintained.

3. Economic analysis

The economic analysis conducted for each topic and intervention followed the same methodology as described in the Methods section. However, as the interventions differ in terms of outcomes reported, costing methodologies, time horizons, perspectives and benefits to child or mother, etc., different analyses had to be conducted to produce comparable results. The following table summarises the data types extracted from each paper and the additional parameters retrieved to complete the economic analysis.

Please note, although the interventions within each intervention group aim for the same outcome, ie increased breastfeeding uptake and reduction in cases of PND, the results from each group cannot necessarily be combined without making assumptions. For instance, it is not known whether if one person participated in both breastfeeding interventions, they would receive a QALY gain equivalent to the sum of the QALY gains from each intervention.

Table 3 - Summary of data extraction

Paper	Intervention	Data extracted from paper	Time horizons	Unavailable data
Hoddinott, 2012	Breastfeeding uptake – Proactive and reactive call	From the paper: • Cost of intervention • Effectiveness of intervention - uptake of breastfeeding From additional sources: • Cost savings and QALY gains achieved due to increase in breastfeeding for both mother and child	• Child benefits: one year (although QALY losses from early mortality are calculated for all life years lost) • Mother benefits: Lifetime	• Longer-term child benefits • Other potential benefits to the mother
Renfrew, 2009	Breastfeeding uptake and child outcomes – Enhanced staff	From the paper: • Cost of intervention	• Child benefits: Lifetime	• Benefits to the mother • Breakdown of the child

Paper	Intervention	Data extracted from paper	Time horizons	Unavailable data
	contact for underweight newborns	• Cost savings and QALY gains achieved due to intervention for child		benefits into number of cases of specific conditions avoided
Morrell, 2016	Midwifery redesigned postnatal care, universal intervention (Macarthur et al., 2002)	From the paper: • Cost of intervention • Cases of PND averted due to intervention From additional sources: • Cost savings and QALY gains achieved due to PND cases averted for both child and mother	• Child benefits: Lifetime • Mother Benefits: up to 10 years after birth	• No specific gaps although breakdown could be more granular
	Peer support intervention for prevention of postpartum depression, targeted intervention (Barnes et al., 2009)			
	Group physical therapy exercises, universal intervention (Norman et al., 2010)			
	Booklet on PND, universal intervention (Sealy et al., 2009)	From the paper: • Cost of intervention • QALY gains to mothers	Mother Benefits: one year	• Cost savings • Child benefits • Longer-term mother benefits • Raw data, eg no of cases
	Early contact with care provider, universal intervention (Gunn et al., 1998)			

Paper	Intervention	Data extracted from paper	Time horizons	Unavailable data
	Calcium prescription, universal intervention (Harrison-Hohner et al., 2001)			
	CBT-based intervention, targeted intervention (Barnes, 2009)			
	Education on preparing for parenting, targeted intervention (Sen, 2006, Zlotnik et al., 2001)			
	IPT-based intervention, targeted intervention (Chabrol et al., 2003)			

Where relevant the primary reference for the intervention study is provided in the intervention column.

Breast feeding

The paper on the proactive and reactive call intervention (Hoddinott, 2012), included information around the cost of the intervention and the effectiveness as measured in increased breastfeeding uptake. To calculate the cost savings and QALY gains due to the intervention for both mother and child, additional parameters were searched that linked breastfeeding with child and mother mortality and healthcare costs. Specifically, the following was retrieved:

- Infant child mortality due to infectious diseases and the relevant odds ratios for children that have been breastfed vs. children that have not (in the first year) – this was used to calculate lifetime QALY loss due to early mortality in the first year;
- Healthcare utilisation and costs of infectious diseases (gastrointestinal illnesses, lower respiratory tract infection, acute otitis media and necrotising enterocolitis (NEC)) and the relevant odds ratios for children that have been breastfed vs. children that have not (in the first year);
- Mother QALY gains due to the number of breast cancer cases averted as a result of the intervention[19]
- Healthcare utilisations and costs of breast cancer and the relevant odds ratios for women that breastfeed versus the women that do not.

Children's QALY gains are calculated by using the reduction in mortality for cases of illness prevented due to the interventions effectiveness. The cost savings were calculated by the reduction in healthcare utilisation and cost for the cases averted due to the intervention. Any benefits beyond the first year were not included. Given the links between breastfeeding and cognitive outcomes and childhood obesity, which are established but were not possible to include in the model,[20] this is likely to be an underestimate of total benefits.

Similarly, the mothers' cost savings were calculated by using the reduction in healthcare utilisation and costs for the breast cancer cases averted due to the intervention. Any other potential benefits to the mother were not included.

The sources of these parameters were:

- Mothers' QALYs sourced from: Renfrew, M.J., Pokhrel, S., Quigley, M. A., McCormick, F., Fox-Rushby, J., Dodds, R. et al. 2012 [cited 28 July 2017] Preventing disease and saving resources: the potential contribution of increasing breastfeeding rates in the UK. Available from http://dspace.brunel.ac.uk/bitstream/2438/10266/1/Fulltext.pdf
- Mortality rate due to infectious diseases: Victora, C.G., Bahl, R., Barros A.J.D., França, G.V.A., Horton, S., Krasevec, J. et al. 2016. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet* 387: 475-90
- All other parameters: Pokhrel, S., Quigley, M.A., Fox-Rushby, J., McCormick, F., Williams, A., Trueman, P. et al. 2015. Potential economic impacts from improving breastfeeding rates in the UK. *Arch Dis Child* 100; 334-340.

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[19] As the paper only referenced first time mothers for this finding, it was only applied it to the proportion of live births from first time mothers. It is unclear if the benefit also applies to subsequent pregnancies.
[20] Unicef. [cited 28 July 2017]. Preventing disease and saving resources: the potential contribution of increasing breastfeeding rates in the UK. Available from https://www.unicef.org.uk/babyfriendly/wp-content/uploads/sites/2/2012/11/Preventing_disease_saving_resources_policy_doc.pdf

The target population of interest for proactive and reactive calls is mothers living in deprived areas. These data were taken from the index of multiple deprivation (IMD) for England.[21] The level of deprivation was split into quintiles and we took the first three quintiles, where one is the most deprived, for our target population. This is following the same methodology as reported in Hoddinott (2012).

The paper on enhanced staff contact for underweight newborns (Renfrew, 2009) presented the cost of the intervention and the cost savings and QALY gains achieved due to the intervention for the child. However, the paper did not report mother benefits. In addition, due to the way that the results were reported, it was not feasible to calculate how many cases of breastfeeding had been incrementally achieved, or how many cases of infectious diseases have been averted due to the intervention. In the ROI tool, therefore, only the benefit to the child as reported by the research paper is included. Data for the proportion of underweight live births in the UK was taken from the Office for National Statistics (ONS)[22] , and combined with additional ONS data[23] to calculate the proportion of these births that fell within our modelled weight categories (500-999g, 1,000-1,749g and 1,750-2,499g).

Postnatal depression

For PND, one systematic review of various interventions was selected for inclusion in the tool (Morrell, 2016). Although the cost of the interventions included in the review was reported, the review did not include any cost savings to the mother or the child. The review presented only the QALY gains for the mothers, as converted from the individual intervention Edinburgh Postnatal Depression Scale (EPDS) scores, and only for a one-year time horizon. To account for this issue, each individual paper included in the review was assessed for other useful reported data. Specifically, for effectiveness evidence and cases of PND averted. The number of PND cases averted for three individual interventions was found:

- midwifery redesigned postnatal care, universal intervention
- peer support intervention for prevention of PND, targeted intervention
- group physical therapy exercises, universal intervention

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[21] Department for Communities and Local Government. 2015 [cited 28 July 2017]. English indices of deprivation 2015. Available from https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

[22] Table 1, 2015 dataset, from Office for National Statistics. [Cited 28 July 2017.] Births by mothers' usual area of residence in the UK. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsbyareaofusualresidenceofmotheruk

[23] Table 5, 2013 dataset, from Office for National Statistics. [Cited 28 July 2017.] Characteristics of Birth 1, England and Wales. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/characteristicsofbirth1englandandwales

Of the six included PND interventions, these three captured the widest range of costs and benefits. As such, for simplicity, this group of interventions will be referred to as the "full" PND interventions in this report and in the tool.

For these interventions, the number of PND cases averted was linked with public sector cost savings and QALY gains for both mother and child. To do this the following parameters were retrieved:

- public sector costs (Health and Social care) of perinatal depression for mothers
- QALY losses due to PND for mothers
- public sector costs (Health and Social care, Education and Criminal Justice) to children as a result of the mother's perinatal depression (benefits on pre-term birth were excluded. The paper used for this analysis covered perinatal rather than just postnatal depression and it was deemed this element related to depression before birth. (It was unclear to what extent other benefits would change if the focus was solely on postnatal depression.))
- QALY losses to the child due to mother's PND

These parameters were taken from an LSE & Centre for Mental Health paper on the topic: Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

The effects to the mother were measured for up to 10 years after birth (accounting for multiple births) while the effects to the children were measured for the child's lifetime.

Some of the rest of the interventions included in the systematic review for which the effectiveness data could not be found in the form of cases of PND averted were also included in the final ROI tool. These interventions did not provide any information on cost savings, but provided data on QALY gains and cost of the intervention. Given this restriction in data availability, these three interventions are referred to as the "basic" PND interventions in this report and within the tool.

For the basic PND interventions, a simple break-even analysis was conducted to calculate, for each intervention, the number of averted PND cases needed in order to make the intervention dominant, ie provide cost-savings and QALY gains. Data provided in the Bauer et al.[24] report on the costs of perinatal mental health problems

[24] Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

was used, specifically the figure related to the monetised benefit of one case of PND averted, to calculate the break-even point.

In the tool, a clear distinction is made between the full and basic interventions.

Overall findings

The overall findings of the economic analysis are summarised below:

Table 4 – summary of economic analysis: Hoddinott et al., (2012)

Paper	Intervention	Net benefit for mother-child dyad	QALY gains for mother-child dyad	ICER
Hoddinott et al., 2012	Breastfeeding uptake – Proactive and reactive call (targeted in deprived areas)	-£1.04	0.00053	£1,939
Included in the analysis:		• Cost of the intervention • Additional breastfeeding uptake • Cost savings and QALY gains achieved for both child (one year only, although QALY losses from early mortality are calculated for all life years lost) and mother (lifetime, from reduced breast cancer risk only) • Health benefits due to reduced child mortality from gastrointestinal illnesses, lower respiratory tract infection, acute otitis media and necrotising enterocolitis (NEC); and reduced cases of breast cancer for the mother		
Not included in the analysis:		• Longer-term child benefits • Other potential benefits to the mother		

Table 5 – summary of economic analysis: Renfrew, (2009)

Paper	Intervention	Net benefit for child		QALY gains for child		ICER
Renfrew, 2009	Breastfeeding uptake and child outcomes – Enhanced staff contact for underweight newborns	500-999g	£563	500-999g	0.25	Dominant for all cases
		1000-1749g	£271	1000-1749g	0.05	
		1750-2500g	£44	1750-2500g	0.01	
Included in the analysis:		- Cost of the intervention - Additional breastfeeding uptake - Cost savings and QALY gains achieved for the child (lifetime) - Health benefits due to reduced child morbidity and mortality from sepsis and necrotising enterocolitis (NEC)				
Not included in the analysis:		- Benefits to the mother - Breakdown of the child benefits into number of cases of specific conditions avoided				

Table 6 – summary of economic analysis: Morrell, (2006) – Full PND interventions

Paper	Intervention	Net benefit for mother-child dyad	QALY gains for mother-child dyad	ICER
Morrell, 2016	Midwifery redesigned postnatal care, universal intervention (Macarthur et al., 2002)	£455	0.127	Dominant
	Peer Support Intervention for prevention of postpartum depression, targeted intervention (Barnes et al., 2009)	£109	0.132	Dominant
	Group physical therapy exercises, universal intervention (Norman et al., 2010)	£491	0.126	Dominant
Included in the analysis:		- Cost of the intervention - Cases of postnatal depression averted due to the intervention - Cost savings		

	• QALY gains achieved for both child (lifetime) and mother (up to 10 years after birth) • Health and other public sector benefits due to reduced depression and suicide in the mother and reduced infant death, emotional problems, conduct problems, special educational needs, and from leaving school without qualifications[25]
Not included in the analysis:	• No specific gaps although breakdown could be more granular

Table 7 – summary of economic analysis: Morrell, (2016) – Basic PND interventions

Paper	Intervention	Net benefit for mother only	QALY gains for mother only	ICER
Morrell, 2016	CBT-based intervention, targeted intervention (Barnes, 2009)	-£103	0.0025	£41,258
	Education on preparing for parenting, targeted intervention (Sen, 2006, Zlontik et al., 2001)	-£277	0.0158	£17,551
	IPT-based intervention, targeted intervention (Chabrol et al., 2003)	-£516	0.0147	£35,083
	Calcium prescription, universal intervention (Harrison-Hohner et al., 2001)	-£82.27	0.0086	£9,566
	Booklet on PND, universal intervention (Sealy at a., 2009)	-£1.12	0.0076	£147
	Early contact with care provider, universal intervention (Gunn et al., 1998)	-£42.72	0.0058	£7,365
Included in the analysis:		• Cost of the intervention • QALY gains to the mother (one year)		

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[25] Benefits on pre-term birth were excluded: the paper used for this analysis covered perinatal rather than just postnatal depression and it was deemed this element related to depression before birth. (It was unclear to what extent other benefits would change if the focus was solely on postnatal depression.) Source for the analysis: Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

	• Health benefits from reduced levels of depression in mothers
Not included in the analysis:	• Cost savings
	• Child benefits
	• Longer-term mother benefits
	• Raw data, eg number of cases

- Please note that the mother-child dyad refers to the **combined** net-benefit and QALY gains for both mother and child.
- Net benefit represents cost savings that result from the intervention less intervention cost.
- All costs and benefits are measured versus the comparator from the original papers, normally usual care.
- Conducting the analysis included sourcing information from beyond the papers listed above.
- The discount rate applied to the outcomes of the intervention drawn from Renfrew is 3.5%, the rate applied to the analysis.
- The default discount rate applied to the outcomes of the intervention drawn from Hoddinott is 1.5%. This rate can be adjusted by the user.
- The discount rate applied for the interventions for Morell (1) is 3.5%. This is the rate applied to the LSE et. al. (2014) calculations, of which the outcomes of these interventions are drawn.
- The discount rate applied for the interventions for Morell (2) is 0%, as no discounting was applied to the analysis with which these interventions are drawn.
- Where relevant the primary reference for the intervention study is provided in the intervention column.

The implication of these results is as follows:

- Of the two breastfeeding interventions, one (enhanced staff contact for underweight newborns) is dominant, and the other (proactive and reactive calls) is cost-effective, with a very low ICER (£1,939 per QALY), compared to the NICE threshold for cost-effectiveness of £20,000-£30,000 per QALY. It is also close to becoming dominant given the net cost is only just greater than £1. It would be expected, that given there are some benefits for these interventions that it was not possible to measure, that this analysis slightly underestimates the benefits and potential cost savings as well.
- The three full PND interventions are all dominant; suggesting they are both cost saving and deliver positive health gains.
- For the six basic PND interventions, the ICERs range from £147 to £41,258, suggesting some are cost-effective but others not. However, these estimates likely overestimate the cost and under estimate the QALY gains significantly. As mentioned above, break-even analysis was carried out for these interventions, with

results summarised for a hypothetical treatment cohort of 10,000, shown in the table below:

Table 4 – Required number of cases averted necessary for basic PND interventions to be dominant compared with equivalent estimated values from full PND interventions

		"Basic" PND interventions		"Full" PND interventions	
		Intervention	Required cases averted (per 10,000 treated)	Intervention	Cases averted (per 10,000)
Targeted interventions		CBT-based intervention,	119	Peer support intervention for prevention of postpartum depression	638
		Education on preparing for parenting,	320		
		IPT-based intervention	596		
Universal interventions		Calcium prescription	95	Midwifery redesigned postnatal care	657
		Booklet on PND	1	and	and
		Early contact with care provider	49	Group physical therapy exercises	650

The smaller the number of cases that need to be averted per 10,000 people treated, the more likely the intervention is to be dominant. By comparing these to the expected cases averted for the full PND interventions (taking into account the universal or targeted nature of the intervention), we can then understand whether the number of cases required to be averted for the basic interventions can reasonably be expected to be achieved.

As shown above, the basic interventions all have lower number of cases to be averted than the full PND interventions. Given the full PND interventions are all dominant over usual care, such results may also indicate that the basic interventions would be too, if evidence supported inclusion of wider costs and benefits in the analysis.

In fact, it is plausible that the two interventions excluded from tool development from the Morrell (2016) review due to their ICERs being above £60,000 (primary care and community care strategies, and selenium (both universal)) could also be cost-effective if further analysis was conducted to link them to number of cases of PND averted.

4.   Economic tool

The tool is designed to allow users to explore outcomes for scenarios varying from the default results. It does this by allowing the user to vary:

- local population numbers
- condition prevalence
- baseline uptake of breastfeeding
- the interventions included and their uptake
- cost
- effectiveness

The user must also input the desired percentage of the eligible population they wish to participate in a particular intervention. This can be done for two scenarios at any given time, which can then be compared to each other and baseline.

There is an introductory set of worksheets providing background information on the project and the aims of the tool in facilitating decision making around public health interventions, aimed at 0-5 year olds and/or pregnant women. Additionally, there is guidance on how to navigate and use the tool. All prices have been uplifted to 2016/17 prices where appropriate. Below is a more detailed description of the tool's inputs and outputs.

Tool inputs

Population(s) and Pop. & Int_description sheet
The tool allows the user to change the population inputs by selecting a geographical area. This can be that of a Clinical Commissioning Group (CCG), the area for a Sustainability & Transformation Partnership (STP), a local authority, a county/unitary authority, a region, or England as a whole. Specific population numbers for each user input is provided as a default in the model, which can be overridden if updated numbers are available. The high-level population of interest is the mother and child dyad, which in this population is proxied by the number of live births per year.[26]

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[26] Total population numbers and number of live births are taken from Table 1, 2015 dataset, from Office for National Statistics. [Cited 28 July 2017.] Births by mothers' usual area of residence in the UK. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsbyarea ofusualresidenceofmotheruk. Adjustments to CCGs and STPs were made using data from the LGA [Cited 28 July 2017] BCF mapping and contacts (https://www.local.gov.uk/sites/default/files/documents/mapping-ccgs-hwbs-and-hwb-507.xlsx) and provided to us by PHE, respectively.

Given the two intervention types included in the tool and the information regarding target populations of the interventions, the populations of interest can be further broken down. With regards to breastfeeding the population disaggregation is as follows:

- proportion of women living in a deprived area (15-50; England)[27]
- women that do not breastfeed[28]
- proportion of live underweight births disaggregated into three weight categories (500-999g; 1000-1749g; 1750-2499g)[29]

With regards to the interventions aimed at maternal mental health, the population disaggregation is as follows:

- proportion of women at risk of PND

Due to a lack of data availability around women at risk of PND, the default proportion for at risk women is the same as the suggested proportion of women with PND as stipulated in the Bauer report[30] on the costs of perinatal mental health problems.

The Pop. & Int._descriptions sheet provides key information including the effectiveness measure, description for the included interventions and comparator information where available, allowing the user to understand exactly what each intervention includes and aims to achieve.

Intervention(s)_PND_Sc1 & Intervention(s)_BF_Sc1 sheets
There are two intervention information sheets – one each for breastfeeding and PND – for scenario 1. The user can select what interventions they would like to see results for, and to include in, the scenario and package analyses. For each intervention, the user must include the percentage of the eligible population desired in each intervention, as

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[27] Department for Communities and Local Government. 2015 [cited 28 July 2017]. English indices of deprivation 2015. Available from https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

[28] Public Health England. 2016. Breastfeeding prevalence at 6-8 weeks after birth. 2015/16 (October 2016 release). Available from https://www.gov.uk/government/statistics/breastfeeding-at-6-to-8-weeks-after-birth-2016-to-2017-quarterly-data

[29] Data combined, from both Table 1, 2015 dataset, from Office for National Statistics. [Cited 28 July 2017.] Births by mothers' usual area of residence in the UK. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsbyarea ofusualresidenceofmotheruk
 and Table 5, 2013 dataset, from Office for National Statistics. [Cited 28 July 2017.] Characteristics of Birth 1, England and Wales. Available from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/characteristi csofbirth1englandandwales

[30] Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

well as having the opportunity to override default figures for the incremental cost and incremental effectiveness of the intervention.

Intervention(s)_Sc2

In the scenario 2 sheet, user selections and inputs for scenario 1 are replicated for reference, with custom boxes available for those who want to compare the differing results of changing key parameters to those selected in scenario 1. The user is able to change the number allocated to each intervention and the incremental cost of all included interventions in scenario 2. However, for the six basic PND interventions, where evidence around the number of cases averted was not available, the incremental effectiveness of these interventions cannot be changed.

Other inputs sheet

In the Other Inputs sheet, the user can input a customised monetary value for a QALY gain or keep the default of £60,000, (as used by the NHS and PHE)[31] and which represents the willingness to pay per QALY value gained.

Tool outputs

Results_BF_Sc1, Results_BF_Sc2, Results_PND_Sc1, Results_PND_Sc2
For each intervention, the tool provides per person and total cost savings, QALY gains (raw and monetised), net benefit (ie net financial cost savings) and ICERs (cost per QALY) for the combined mother and child dyad where possible. In addition to the quantitative findings, qualitative findings are also reported. For instance, with regards to the PND interventions with full information, the number of avoided cases of postnatal depression, in the selected intervention cohort, can be reported. For the other PND interventions, the break-even number of PND cases avoided needed in a given cohort, to achieve a dominant intervention, is provided.

Packages and Charts sheet

The packages sheet provides quantitative information regarding the scenarios selected by the user. Here the PND interventions have been grouped by the level of analysis conducted ie full and basic interventions. Given that the effect of an individual participating in more than one intervention is unknown, combined results are shown for three possible circumstances, based on assumptions:

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[31] Consistent with the willingness to pay value used for QALYs by the NHS and PHE. See for example: Department of Health. 2011 [cited 3 Aug 2017]. Impact Assessment. Improving Outcomes; A Strategy for Cancer. Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213768/dh_123505.pdfAvailable from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213768/dh_123505.pdf

- an assumption that uptake of each intervention is by different people, and thus results can be aggregated (the cumulative approach)
- an assumption that where it is possible for a person to be participating in more than one intervention, that is the case, and – to be conservative – effectiveness is capped at the most effective single intervention (the conservative approach)
- an average of the two scenarios described above (the average approach).

The breastfeeding interventions have not been grouped together to create a package and, therefore, results are reported separately. This is primarily due to the different population groups each intervention is targeting: the proportion of women living in a deprived area in England, and the proportion of live underweight births respectively. The benefits of breastfeeding a child born underweight are somewhat different to that of a normal weight baby and results should therefore not be conflated.

The tool, and specifically the 'packages' tab, provides a selection of metrics for a number of comparisons: scenario 1 vs a 'usual care' situation (ie the comparators from the original papers), scenario 2 vs a 'usual care' scenario and scenario 2 vs scenario 1.

The presented metrics are:

- the total cost of interventions
- total cost savings
- total net benefit
- total QALY gain
- overall ICERs (one using intervention cost only, ie without cost savings, and one including net benefits)
- the benefit-cost ratio
- total value (including the monetised value of the QALY gain – note that this is not a financial gain).

The chart sheet then provides graphical representation of key scenario outputs, namely:

- QALYs gained
- benefit-cost ratio
- total cost of intervention
- total cost savings
- total net benefits.

Indicative case study

The model allows the option for the user to provide the cost of an intervention for a cohort of people within specific population groups, who have been selected for a specific programme/intervention. The tool includes default cost and effectiveness of the

included interventions and calculates ROI metrics including cost savings, net benefit and ICERs alongside health gains to the both mother and child (where applicable) of each intervention.

In this example, a decision-maker in Lancaster is considering implementing a universal intervention to reduce the risk of developing PND, through redesigned midwifery postnatal care. This decision-maker must select what proportion of the population of interest participates in the intervention, in the modelled scenario. In this example, the user selects 10% of their population of interest, in this case, women at risk of PND, to participate – 145 people, with all other default figures unchanged.

Using results derived from Morrell (2016), and extra parameter information and data from the Bauer report[32] on perinatal depression, a cohort of 145 women participating in this intervention creates a per-child cost saving of £458 and QALY gain of 0.079, and a per-mother cost saving of £111 and QALY gains of 0.048. For the whole cohort of 145 women, this equates to combined (both mother and child) cost savings of £82,291, combined QALY gains of 18.371 (valued at £1.1 million), and a combined net benefit of £65,796. These benefits are assumed to be sustained for up to 10 years for the mother and up to lifetime for the child.

The user is also able to look at packaged results for PND interventions, which have been split into two types: the three full PND interventions that can be packaged together as a full economic analysis was undertaken (coded PND_full in the model) and six basic PND interventions that can be packaged together (coded PND_basic in the model).

The aforementioned intervention is a full intervention. The decision-maker now wants to see packaged results for the three full interventions. The second intervention is aimed specifically at women at risk of PND and is a peer support intervention for the prevention of PND. The user selects 30% of the eligible population to participate – 56 women. The third intervention is a universal intervention; the user selects 15% (217 women) of the eligible population to participate. All default figures remain unchanged. The user also has the chance to compare packages of interventions in a scenario analysis; the differences between scenario 1 and scenario 2 are detailed in **Table** 5, with the user keeping the same number of people assigned to each intervention, but changing the cost and effectiveness of each intervention.

Table 5 – Scenario analysis information

Intervention name	Inputs	Scenario 1	Scenario 2

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[32] Bauer, A., Parsonage, M., Knapp, M., Iemmi, V. and Adelaja, B. [cited 28 July 2017] The costs of perinatal mental health problems. LSE Personal Social Services Research Unit & Centre for Mental Health. Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8Available from https://www.centreformentalhealth.org.uk/Handlers/Download.ashx?IDMF=07afd94b-92cb-4e47-8439-94cbf43548d8

Midwifery redesigned postnatal care, universal	Number of participants	145	145
	Cost of intervention	£114	£80
	Effectiveness of intervention	6.6%	4%
Peer support intervention for prevention of postpartum depression, selective	Number of participants	56	56
	Cost of intervention	£483	£550
	Effectiveness of intervention	6.8%	8%
Group therapy exercises, universal	Number of participants	217	217
	Cost of intervention	£72	£50
	Effectiveness of intervention	6.5%	5%

Table 6 and

Figure 5 show the results of the scenario analysis for the cumulative approach. The user is able to easily compare how changes in effectiveness, costs and/or participants can affect outcomes, providing flexibility to the tool to allow for more tailored analysis. As another example, the user can select just one intervention within the package, and change parameters in scenario 1 and 2 to see how these changes affect results.

Table 6 – Scenario analysis: QALY and benefit: cost ratio results

	QALYs gained	Benefit : Cost Ratio
Scenario 2 vs Scenario 1	-12	-0.57
Scenario 1 vs do nothing	53	4.01
Scenario 2 vs do nothing	41	3.44

Figure 5 – Scenario analysis: Costs and cost-savings results
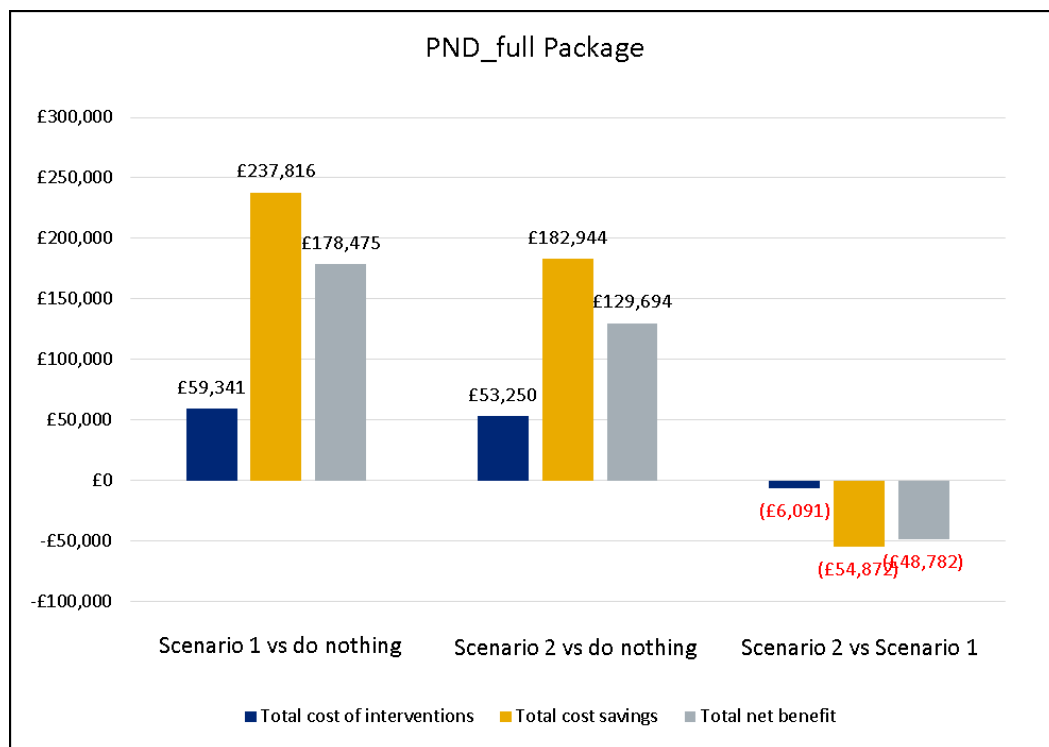
Note that in this example, none of the basic PND interventions, and neither of the breastfeeding interventions were selected, but the process remains the same for these, with the exception of being able to view combined results for the breastfeeding interventions.

5. Conclusions

The aim of the ROI tool is to provide a useful resource for making local investment decisions related to 0-5 year olds and/or pregnant women. It does this by providing ROI metrics, and some qualitative information, for a series of interventions related to breastfeeding and PND. This is complemented by the introduction of geographically specific data and the possibility for the user to run two scenarios including custom data.

However, due to the scope of this piece of work and the evidence available, it was not possible to include a broader range of interventions associated with the Best Start in Life (0-5 years). Although breastfeeding and PND are the two areas included in the model, it does not mean that these are necessarily the most cost-effective areas in which to invest. It is not possible to make such a comparison with the available evidence. Similarly, areas that were excluded during the development of the tool are not necessarily any less cost-effective; rather the evidence was not sufficient to conduct an economic assessment without significant extra parameter searching and analysis.

As such, a key recommendation is that more research is directed towards developing further economic analyses of interventions associated with the Best Start in Life (0-5 years).

It is also recommended that future economic research looks to incorporate results in natural units alongside the standard cost-effectiveness metrics. This will facilitate more intuitive comprehension and an understanding of what QALY gains and cost savings are driven by, and to help future research link outcome studies to intervention studies.

For the interventions that were included, there is a strong case to be made that many of them are very cost-effective or dominant (ie cost saving and effective). Of the two breastfeeding studies, one was dominant (enhanced staff contact for underweight newborns) and one was very cost-effective (proactive and reactive calls) with a small additional cost and an ICER under £2,000.

Of the PND interventions, those able to be linked to longer-term outcomes (ie the full interventions) were all dominant. It was unfortunate that within the scope of this study it was not possible to link the basic PND interventions to longer-term outcomes. This was largely because, although cost and QALY data was reported in the source study, 'raw figures', ie results in natural units, such as the number of cases of PND avoided, were not calculated. However, the break-even analysis suggests that all of these PND interventions could be dominant. There is therefore a strong case to be made for investment in all these interventions.

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7. Appendices

Appendix A:

Interventions with ROI metrics from NICE's Children and Young People and Pregnant Woman (CYP) and Social and Emotional Wellbeing (SEW) ROI tools

The NICE CYP and SEW tools cover a wide range on interventions, but only a small number were subject to full economic analysis. Only interventions with were included as cost-effectiveness analysis (CEA) in the NICE tools were excluded from the Best Start in Life tool. Any intervention only summarised through a cost-consequence analysis (CCA) was still eligible for inclusion.

Table A1 – Interventions covered by CEA in the NICE CYP tool and therefore excluded in this project

Behaviour metric	Intervention
Reduction in children aged under 18 who drink four or more units per week	Classroom based skills-based activities to reduce alcohol consumption
Reduction in children aged under 18 who drink four or more units per week	School curriculum designed to educate children and reduce alcohol consumption
Increase in physical activity	Walking buses
Increase in physical activity	Health counselling sessions
Reduction in bullying victimisation	Anti-bullying programme
Reduction in children aged under 18 who drink four or more units per week	Ban of alcohol television advertising to under 18 year olds
Increase in employment	Transition support services – Independent Living Programmes
Smoking cessation	Self-help and goal setting
Smoking cessation	Brief advice
Smoking cessation	Counselling
Smoking cessation	Cognitive Behaviour Therapy
Smoking cessation	Quit support with booklets

Behaviour metric	Intervention
Smoking cessation	Incentive vouchers

Behaviour metric	Intervention
Smoking cessation	Incentive vouchers

Table A2 – Interventions covered by CEA in the NICE SEW tool and therefore excluded in this project

Behaviour metric	Intervention
Reduction in bullying victimisation	Anti-bullying
% increase in full-time employment	Transition support services – Independent Living Programme

Appendix B: Search Strategy and database search results

The search strategy below was used for the Embase database and consequently adapted for the other databases searched.

Embase

1   pregnan*.ti,ab. (529067)
2   pregnant woman/ (70411)
3   pregnancy/ (675980)
4   gravid*.ti,ab. (14802)
5   "child bearing".ti,ab. (3367)
6   childbearing.ti,ab. (12457)
7   antenatal.ti,ab. (37753)
8   prenatal care/ (33830)
9   maternity.ti,ab. (19950)
10   maternal care/ (16058)
11   perinatal.ti,ab. (77204)
12   perinatal care/ (13237)
13   child*.ti,ab. (1439059)
14   child/ (1644492)
15   infant*.ti,ab. (400751)
16   infant/ (604582)
17   newborn*.ti,ab. (170670)
18   newborn/ (541923)
19   under-5*.ti,ab. (11777)
20   "under five*".ti,ab. (4792)
21   pre-school*.ti,ab. (5341)
22   kindergarten/ (2999)
23   kindergarten*.ti,ab. (5842)
24   nurser*.ti,ab. (10141)
25   nursery/ (4450)
26   nursery school/ (1414)
27   1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 (3392668)
28   prevention.ti,ab. (549443)
29   prevention/ (377389)
30   intervention*.ti,ab. (968607)
31   intervention study/ (43107)
32   education*.ti,ab. (536597)
33   support.ti,ab. (953622)

34   advice.ti,ab. (54171)
35   signpost*.ti,ab. (759)
36   referral*.ti,ab. (127357)
37   patient referral/ (81106)
38   class*.ti,ab. (1382814)
39   "risk assessment*".ti,ab. (60544)
40   risk assessment/ (417925)
41   safeguard*.ti,ab. (9997)
42   "child protection".ti,ab. (1887)
43   child protection/ (396)
44   "public health intervention*".ti,ab. (4418)
45   28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44
(4463189)
46   "health visit*".ti,ab. (3879)
47   health visitor/ (1965)
48   (breastfeed* adj5 advice).ti,ab. (212)
49   (breastfeed* adj5 advis*).ti,ab. (130)
50   breast feeding education/ (2338)
51   (breastfeed* adj5 educat*).ti,ab. (1004)
52   (breastfeed* adj5 support*).ti,ab. (2080)
53   nutrition*.ti,ab. (280536)
54   nutrition/ (128067)
55   nutrition education/ (4660)
56   nutrition service/ (534)
57   "physical* activ*".ti,ab. (108471)
58   physical activity/ (123806)
59   (obesity adj2 prevent*).ti,ab. (7487)
60   "oral health".ti,ab. (17953)
61   behaviour.ti,ab. (205200)
62   behavior.ti,ab. (543785)
63   "drug use"/ (111324)
64   substance abuse/ (54250)
65   immunisation*.ti,ab. (10541)
66   immunization/ (101037)
67   immunization*.ti,ab. (96524)
68   "mental health".ti,ab. (125595)
69   mental health/ (128629)
70   "home safety".ti,ab. (537)
71   home safety/ (590)
72   (accident* adj3 prevent*).ti,ab. (3854)
73   accident prevention/ (17097)
74   (injur* adj3 prevent*).ti,ab. (22127)
75   "public health nurs*".ti,ab. (4417)
76   "home visit*".ti,ab. (8495)
77   (Child* adj3 "health nurs*").ti,ab. (436)
78   (family adj3 "health nurs*").ti,ab. (196)
79   "Plunket nurs*".ti,ab. (20)
80   "post-natal depression".ti,ab. (188)
81   "postnatal depression".ti,ab. (3250)
82   puerperal depression/ (8534)
83   "peri* depression".ti,ab. (1000)
84   "puer* depression".ti,ab. (62)
85   parenting.ti,ab. (14927)
86   child parent relation/ (46256)
87   weaning.ti,ab. (32501)
88   weaning/ (25043)
89   ((identif* or detect*) adj3 ((domestic or spousal or child) adj2 (abuse or violence))).ti,ab. (549)
90   diet/ (260371)

91   nutrition/ (128067)
92   diet.ti,ab. (330943)
93   nutrition*.ti,ab. (280536)
94   "dental health".ti,ab. (7367)
95   dental health/ (3898)
96   "child development".ti,ab. (6279)
97   child development/ (43483)
98   neglect*.ti,ab. (55950)
99   child neglect/ (2718)
100   "nurs* partnership*".ti,ab. (114)
101   "healthy child programme".ti,ab. (21)
102   "family partnership model*".ti,ab. (16)
103   ((smoking or alcohol*) adj5 (pregnan* or gravid* or "child bearing" or childbearing or parent* or caregiver*)).ti,ab. (17123)
104   46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 or 100 or 101 or 102 or 103 (2170047)
105   cost-effective*.ti,ab. (135276)
106   "cost effectiveness analysis"/ (128791)
107   cost-benefit*.ti,ab. (12399)
108   "cost benefit analysis"/ (76075)
109   cost-utilit*.ti,ab. (5265)
110   "cost utility analysis"/ (8106)
111   "return* on investment*".ti,ab. (1714)
112   cost-saving*.ti,ab. (22459)
113   cash-releas*.ti,ab. (8)
114   economic*.ti,ab. (251355)
115   economics/ (225619)
116   economic evaluation/ (15484)
117   health economics/ (37313)
118   cost*.ti. (127140)
119   (value adj2 (money or monetary)).ti,ab. (2440)
120   "quality adjusted life".ti,ab. (13364)
121   QALY*.ti,ab. (13448)
122   "willingness to pay".ti,ab. (5503)
123   105 or 106 or 107 or 108 or 109 or 110 or 111 or 112 or 113 or 114 or 115 or 116 or 117 or 118 or 119 or 120 or 121 or 122 (734102)
124   27 and 45 and 104 and 123 (11533)
125   exp Great Britain/ (7126)
126   exp United Kingdom/ (411150)
127   (gb or "g.b." or britain* or (british* not "british columbia") or uk or "u.k." or "united kingdom*" or (england* not "new england") or ireland* or irish* or scotland* or scottish* or ((wales or "south wales") not "new south wales") or welsh*).ti,ab,jw,in. (2848855)
128   nhs*.ti,ab,in. (186175)
129   exp Ireland/ (31681)
130   exp Canada/ (166176)
131   (canada* or canadian*).ti,ab,jw,in. (1133916)
132   exp "australia and new zealand"/ (202918)
133   (australia* or "new zealand*").ti,ab,jw,in. (927938)
134   exp United States/ (1208521)
135   (USA or "united states").ti,ab,jw,in. (8026235)
136   (america* not ("central america*" or mexic*)).ti,ab,jw,in. (2695708)
137   125 or 126 or 127 or 128 or 129 or 130 or 131 or 132 or 133 or 134 or 135 or 136 (13723712)
138   exp Africa/ (282715)
139   exp Asia/ (885963)
140   exp Antarctica/ (5855)
141   exp Arctic/ (7358)

142   138 or 139 or 140 or 141 (1153621)
143   exp United Kingdom/ (411150)
144   exp Ireland/ (31681)
145   exp Canada/ (166176)
146   exp "australia and new zealand"/ (202918)
147   exp United States/ (1208521)
148   143 or 144 or 145 or 146 or 147 (1939982)
149   142 not 148 (1079765)
150   137 not 149 (13457168)
151   124 and 150 (6114)
152   limit 151 to yr="2009 -Current" (3408)
153   limit 151 to (english language and yr="2009 -Current") (3387)

Appendix C: Inclusion and exclusion criteria

	Criteria	Result	Code	Notes
Q1	POPULATION Children 0-5 Pregnant women	YES/UNCLEAR – go to Q2	If not **EX.POP**	
Q2	DATE Published after 2009	YES/UNCLEAR – go to Q3	If not **EX.DATE**	
Q3	COUNTRY UK, Ireland, Canada, New Zealand, USA	YES/UNCLEAR – go to Q4	If not **EX.COUNTRY**	
Q4	TOPIC 1 Are interventions delivered by health visitor or equivalent?	YES – go to Q5 and go to Q8 NO/UNCLEAR – go to Q5	**QUERY** If yes, go to Q5 and Q8 If not, go to Q5	
Q5	ECONOMICS Does the study report economic analysis or costs?	YES/UNCLEAR – go to Q6	If not **EX.ECON**	
Q6	TOPIC 2 Public health interventions aimed at population in Q1	YES – go to Q7	If not **EX.TOPIC2**	

	Criteria	Result	Code	Notes
Q7	STUDY DESIGN • cost-benefit analysis • cost-effectiveness study • cost-utility analysis • cost analysis (including CCA) • primary research study including relevant economic information (eg unit costs) • Systematic reviews any of the above studies	YES/UNCLEAR - retrieve full text	Studies that are an economic evaluation: **IN.ECON_NUTR/PHISICAL** **IN.ECON_ORAL** **IN.ECON_IMMUN** **IN.ECON_EDUC** **IN.ECON_MATERNAL** **IN.ECON_OTHER** Studies that report useful cost and resource data include as: **IN.COST** Systematic reviews that include any of the study types: **IN.SYSTREV**	Nutr/Physical: diet, breastfeeding, childhood obesity, vitamins, physical activity, exercise Educ: educational attainment, behavioural interventions Maternal: antenatal and postnatal physical health, postnatal mental health, smoking cessation, substance misuse Other: eg home safety, parenthood interventions, etc. Please add the topic area in the comments field if possible IT IS POSSIBLE TO INCLUDE USING SEVERAL CODES, SELECT ALL THE RELEVANT INCLUSION CODES
Q8	HEALTH VISITORS Does the study present quantitative measures of effectiveness?	ANY	If yes **IN.HV** If not, but provides interesting context, **IN.HV** If not relevant at all, **EX.TOPIC1**	Equivalent occupations: • UK: Health visitor • US: Public health nurse • Canada: Public health nurse / home visitation • Ireland: Public health nurse • Australia: Child & family health nurse • New Zealand: Plunket nurse http://ihv.org.uk/our-work/international/

Appendix D:

Summary of interventions / topics – Included / Excluded for modelling

Obesity

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/exclusion
Multicomponent obesity intervention	Hayes,2016	Excluded	Excluded due to results not significant
Multicomponent obesity intervention	Rawdin, 2014	Excluded	Excluded due to uncertainty about applicability of results to the UK
Home visiting -nutritional and physical activity advice for mother & child	Hayes, 2014	Excluded	Excluded as only one Australia based study which would already be included in the health visitor report.
Family counselling programme for overweight/obese children	Aria, 2015	Excluded	Excluded on lack of feasibility to model
Supported lifestyle change - home visiting and telephone support	Wright D, 2014	Excluded	Excluded on lack of feasibility to model
Multicomponent diet, physical activity and health education programme	Bond, 2010	Excluded	No QALYs, cost savings or healthcare utilisation outcomes or overall cost-effectiveness measures reported
Multicomponent diet, physical activity and health education programme	Bond, 2009	Excluded	One study was not effective, the other two were not transferable to general UK context
Multicomponent diet, physical activity and health education programme	Carter, 2009 (review)	Excluded	•TravelSmart Schools – not cost effective •Walking School Bus – not cost effective •Active after school community programmes – not cost effective
Multicomponent diet, physical activity and health education programme	Cawley, 2010	Excluded	Target population is children in middle school
Multicomponent diet, physical activity and health education programme	Gortmaker, 2016	Excluded	All interventions in review beyond scope of project (incorrect target population)

Multicomponent diet, physical activity and health education programme	Laws, 2013	Excluded	No QALYs, cost savings or healthcare utilisation outcomes or overall cost-effectiveness measures reported
Multicomponent diet, physical activity and health education programme	London Assembly, 2015	Excluded	•MEND: "Mind, Exercise, Nutrition… Do It!" - No economic information on the intervention targeted at 2-4 year olds •LEAP: Local Exercise Action Plans - No economic reviews of the intervention and targets general population •Planet Health - Target population is children in middle school •CATCH: Coordinated Approach to Child Health - Target population is children in middle school •Lifestyle counselling by GPs - Not been effective in terms of BMI, nutrition improvements or physical activity in children classed as overweight or obese
Multicomponent diet, physical activity and health education programme	McCollister, 2011	Excluded	No QALYs, cost savings or healthcare utilisation outcomes or overall cost-effectiveness measures reported

Immunisation

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/ exclusion
MMR Education	Tubeuf, 2014	Excluded	Unlikely to be generalisable to a UK context or to have a significant impact
Increasing preschool immunisation in low income children	Unable to retrieve	Excluded	Paper unavailable

Maternal Mental Health

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/exclusion
Group Cognitive Behavioural Therapy (CBT)	Stevenson, 2010	Excluded	The cost per QALY ratio for group CBT in PND was uncertain because of gaps in the evidence base. There was little quantitative or qualitative RCT. evidence to assess the effectiveness of group CBT for PND. The evidence that was available was of low quality in the main because of poor reporting of the results.

Multicomponent intervention targeted at mothers suffering post-natal depression	Morrell, 2016 (review)	Included	
Specialist HV assessment combined with behavioural or clinical treatment of mothers suffering post-natal depression	Morrell, 2009	Excluded	Excluded due to uncertainty about costing approach

Parental Mental Health

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/ exclusion
Psychoeducational parental education support via group support sessions	Ride, 2016	Excluded	Excluded on there being no statistically significant difference in outcomes between control and intervention groups. Additionally, there was a high level of uncertainty surrounding the effectiveness of the intervention

Parenting skills and child education

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/exclusion
Multicomponent parental support	Charles, 2011	Excluded	[Not excluded but focus on a different topic: conduct disorder]
Multicomponent parental support	Maher, 2012	Excluded	Based in the US with few details on the interventions costs which seem very context dependent even within the study population.
Multicomponent parental support	NHS, 2015	Excluded	Study protocol

Parenting skills

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/exclusion
Group based parenting support	Simkiss, 2013	Excluded	Results showed no statistically significant difference between control and intervention arm
Home visiting support	McIntosh, 2009	Excluded	Difficulty with linking outcomes of study (maternal sensitivity and infant cooperativeness) to QALYs
Incentives for improved parenting	Gross, 2011	Excluded	Results showed no statistically significant difference between control and intervention arm
Parental education and training	Jones DE, 2014	Excluded	Difficulty linking outcome to QALYs/longer term impacts

Parental education for maltreatment prevention	Sege, 2014	Excluded	Results showed no statistically significant difference between control and intervention arm
Various intervention targeting child growth and development and parenting skills interventions	Batura, 2015 (review) *Some studies in this category*	Excluded	•Muntz et al. (2004) – Difficulty linking outcome to QALYs/longer term impacts •Edwards et al. (2007) – Difficulty linking outcome to QALYs/longer term impacts •Barlow et al. (2007) – Improvements in sensitivity and attunement of high-risk mothers and infant cooperativeness found but it would be very difficult to link this with QALYs gained. Paper otherwise only reports costs of control and intervention arms. •Bywater et al. (2011) – Due to small sample size and highly skewed cost data, a cost-effectiveness analysis was unable to be performed. •O'Neil et al. (2011) – Difficulty linking outcome to QALYs/longer term impacts •Bonin et al. (2011) – Child behaviour management - not shortlisted

Breastfeeding

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/ exclusion
Breastfeeding Support	Renfrew, 2009	Included	
Breastfeeding Support	Ma, 2013	Excluded	Though cost savings/healthcare utilisation outcomes are reported, no QALYs or cost savings or reported
Multiple child development and nutrition improvement	Batura, 2015 (review) *Some studies in this category*	Included	•Hoddinot et al (2012) – Intervention: daily calls by feeding team (ward based) to women during first 2 weeks after hospital discharge.
Multiple child development and nutrition improvement	Batura, 2015 (review) *Some studies in this category*	Excluded	•Rice et al (2012) – excluded as duplicate study (Renfrew, 2009) •Chola et al (2011) – excluded due to country criteria (Uganda) •Desmond et al (2008) – excluded due to country criteria (South Africa)

Home safety education and injury prevention

Intervention Type	Paper	Included/ Excluded	Reason for inclusion/exclusion

Health professional home visits	Dalziel, 2012 (review)	Excluded	No intervention deemed cost-effective - provides ICER per case of maltreatment avoided, but difficult to understand how effectiveness is measured when the review includes 33 different effectiveness programmes that measure a range of outcomes (from emergency department attendance to death)
Home safety equipment installation	Pearson, 2009 (review)	Excluded	No QALYs, cost savings or healthcare utilisation outcomes or overall cost-effectiveness measures reported
Home safety interventions	Achana, 2015	Excluded	No intervention deemed cost-effective - provides ICER per case of poisoning avoided, but ICER (£/QALY) for all interventions above NICE recommended £20,000 - £30,000 (lowest was £41k+)
Home visiting Parenting programmes on childhood injuries or home safety	Kendrick, 2013	Excluded	Review of effectiveness studies with no clear descriptions of intervention and no costs associated. 10 RCTs used to do meta-analysis re parenting interventions for the prevention of unintentional childhood injuries. RR of 0.83 int. vs. control.
Various interventions targeting safety education, injury prevention & free/low cost equipment giveaway/fitting	Saramago, 2014	Excluded	No intervention is cost-effective according to NICE guidelines under base case (intervention with lowest £/QALY = £36,000). This intervention only becomes cost-effective under sensitivity analysis when assuming 1.8 children under the age of 5 in a household.

Appendix E: Full data extraction for included papers

Please note that where information was not reported, these rows have been deleted.

All short listed studies underwent a full data extraction, however, only those papers taken forward to inclusion in the tool are presented below. Please note that the 'feasibility to model' score did not dictate whether the intervention was modelled – some interventions marked 'poor' were included if it were possible to link them to other studies and/or to report their aggregated results.

Bibliographic reference	Hoddinott, 2012 (from Batura, 2015)
Study type	RCT
Country	UK
Setting	Maternity unit serving a mixed urban and rural population in Scotland
Intervention topic or impact area	Breastfeeding
Type of intervention	Breastfeeding support
Intervention	Proactive and reactive call after discharge from hospital
Comparator	Only reactive call
Number of participants	69 women (35 in intervention arm, 34 in control arm)
Participants characteristics	Women from SIMD 1, 2 and 3 areas (deprived), mean age: 27.5 Feeding at hospital discharge: - Exclusive BM: 26 vs 27 - Any BM: 35 vs 34
Methods of analysis	Descriptive statistics A generalised linear model with Poisson link function and robust SE was used to estimate the effect of the intervention
First order outcomes	Any breastfeeding at six to eight weeks
Secondary outcomes	Exclusive breastfeeding at six to eight weeks, satisfaction with breast feeding help in hospital and at home, number of days readmitted to hospital (mother or baby) and contact with health professionals following hospital discharge
Limitations	It is likely that the effect sizes are overestimated as the sample size was small
Additional comments	Barely significant results
Study quality	Moderate
Intervention costs	£41.25
Comparator costs	£21.13
All outcome probabilities	Feeding at six to eight weeks after hospital discharge, any breast milk (probability): Intervention arm: 0.69 Control arm: 0.46 Feeding at six to eight weeks after hospital discharge, exclusive breast milk (probability): Intervention arm: 0.53 Control arm: 0.31

Bibliographic reference	Hoddinott, 2012 (from Batura, 2015)
Outcome cost savings	Cost to achieve outcome gain (change in behaviour – any BM): £87 per additional woman Cost to achieve outcome gain (change in behaviour – exclusive BM): £91 per additional woman
Outcome utility/QALY gains	Not reported
Perspectives used	Healthcare provider (UK)
Time horizons	Six to eight weeks after discharge
Discount rate	Not used
Feasibility of modelling	Yes – more parameters are needed
Extra parameters needed	Baseline population of no breastfeeding QALY gain to infant for exclusive BF, any BF, no BF for first six to eight weeks after discharge Costs for infant due to exclusive BF, any BF, no BF for first six to eight weeks after discharge
Feasibility to model	Strong

Bibliographic reference	Renfrew, 2009
Study type	Systematic review and economic analysis
Country	Various (done for the UK)
Setting	Infants born earlier and smaller, weight <= 2500g
Intervention topic or impact area	Breastfeeding
Type of intervention	Breastfeeding support
Intervention	Enhanced staff contact (milk expression and BF)
Comparator	Normal staff contact
Number of participants	Varies
Participants characteristics	All mothers with infants in neonatal units with infants born underweight: Infants were premature (ie < 37 weeks' gestation) or Low birth weight (≤ 2500g) Subgroups were: 500–999g; 1000–1749g; and 1750–2500g

Bibliographic reference	Renfrew, 2009
Methods of analysis	Economic modelling
First order outcomes	Sepsis, confirmed NEC, mortality
Secondary outcomes	Long term disabilities
Additional comments	The study has developed a second model taking into account donor milk as a substitute to formula in the case where the MM is supplemented. The donor model has not been reported as currently in the UK donor milk is neither widely nor readily available. However, the use of donor milk makes the intervention less effective
Study quality	Directly applicable, minor limitations
Intervention costs	Breastfeeding for infants 500-999g: Intervention: £121 Treatment (NEC, Sepsis): £55,572 Long term disability: £31,065 Total: £86,759 Breastfeeding for infants 1000-1749g: Intervention: £121 Treatment (NEC, Sepsis): £38,159 Long term disability: £18,666 Total: £56,947 Breastfeeding for infants 1750-2500g: Intervention: £121 Treatment (NEC, Sepsis): £22,648 Long term disability: £24,458 Total: £47,228
Comparator costs	Breastfeeding for infants 500-999g: Intervention: £0 Treatment (NEC, Sepsis): £56,405 Long term disability: £30,939 Total: £87,345 Breastfeeding for infants 1000-1749g: Intervention: £0 Treatment (NEC, Sepsis): £38,527 Long term disability: £18,712 Total: £57,240

Bibliographic reference	Renfrew, 2009
	Breastfeeding for infants 1750-2500g: Intervention: £0 Treatment (NEC, Sepsis): £22,816 Long term disability: £24,478 Total: £47,294
All outcome probabilities	Reported but calculations are needed
Outcome cost savings	Difference between intervention and control arm for Sepsis, NEC and Long-term disability Incremental cost: -£586 Difference between intervention and control arm for Sepsis, NEC and Long-term disability Incremental cost: -£293 Difference between intervention and control arm for Sepsis, NEC and Long-term disability Incremental cost: -£66
Outcome utility/QALY gains	QALY gains due to intervention: 14.70 QALY gains due to control 14.45 Incremental QALY gain: 0.25 QALY gains due to intervention: 21.05 QALY gains due to control 21.00 Incremental QALY gain: 0.05 QALY gains due to intervention: 21.92 QALY gains due to control 21.91 Incremental QALY gain: 0.01
Perspectives used	Healthcare provider (UK)
Time horizons	Lifetime
Discount rate	3.5% for costs and utility
Feasibility of modelling	Partially – the study examines underweight infants
Extra parameters needed	Proportion of infants born underweight (specific sub-groups probabilities are required)
Feasibility to model	Moderate

From Systematic review	Morrell, 2016					
Intervention topic or impact area	Maternal mental health					
Type of intervention	Multi-component intervention targeted at mothers suffering postnatal depression					
Study quality	Directly applicable, minor limitations					
Intervention	Health visitors giving cognitive behavioural therapy counselling	PND treatment in a specialised PBDU	Not an intervention – measuring total healthcare resources used at 11 weeks between depressed and not depressed women. The "intervention" is not depressed women	Volunteer telephone-based peer support	Primary care and community-based interventions to promote the health of new mothers	Enable midwifery care in community settings to be tailored to women's individual needs with a focus on the identification and management of physical and psychological health
Comparator	Usual care (details not provided)	Routine Primary care (details not provided)	Depressed women	Assume usual care	Control areas (details not provided)	Control group (details not provided)
Population	All postnatal women	Women with PND	Employed postnatal women (depressed and not depressed women)	High-risk women (screened postnatally)	All postnatal women in study areas	All postnatal women in selected GP clusters

From Systematic review	Morrell, 2016				
Intervention cost	Per treated woman = £109	£607	US$365	CA$4497	Average cost per women in rural area = AUS$129; Average cost per women in urban area = AUS$172 *No significant difference in healthcare resource use in intervention areas compared to control areas	£470 total costs (inc. £190 postnatal care costs)
Comparator cost	Per treated woman = £107	£1,238	US$1046	CA$3380		£542 total costs (inc. £190 postnatal care costs)
Net cost (savings)	Non-significant decrease in mean costs occurred overall	Additional cost of (£1,945 per successfully treated woman (compared to CAU)**contradicts cost table	US$681 (saving)	CA$(1,117.00)		£72
Cost-effectiveness			Mean total cost for health-care resources used was US$681 higher in the depressed group than in the non-depressed group	ICER per case of PND avoided = CA$10,009		ICER per case of probable depression prevented = £700
Country	England	England	USA	Canada	Australia	England

From Systematic review	Morrell, 2016					
Original paper	Appleby, 2003	Boath, 2003	Dagher, 2012	Dukhovny, 2013	Gold, 2007	MacArthur, 2003
Extra notes	No cost-effectiveness or QALYs reported	No cost-effectiveness or QALYs reported	Not a specific intervention – looking at resource use of depressed and not depressed postnatal women	No QALYs reported. Based in Canada so may be issue with transferability.	No cost-effectiveness or QALYs reported. Based in Australia so possibility of transferability	No QALYs reported but comparator likely to be relatively easy to cost up and extra parameters to find as it is a UK study
Feasibility to model	Poor	Poor	Poor	Moderate	Moderate	Strong

From Systematic review	Morrell, 2016 (continued)						
Intervention topic or impact area	Maternal mental health						
Type of intervention	Multi-component intervention targeted at mothers suffering postnatal depression						
Study quality	Directly applicable, minor limitations						
Intervention	Additional postnatal care by trained community postnatal support workers	Health visitor psychologically informed training intervention	Additional health visitor visits	Not reported	Screening for PND (EPDS and BDI)	Group CBT for women with PND	Screening for PND (three-question questionnaire)
Comparator	CAU	N/A	N/A	N/A	Assume usual care	Assume usual care	Assume usual care
Population	Postnatal women	At-risk women (screened postnatally) and all postnatal women	At-risk women (screened antenatal)	High-risk women	All postnatal women	Women with PND	All postnatal women

From Systematic review	Morrell, 2016 (continued)						
Intervention cost	Total resources = £815	All women: control = £272, CBA = £253, PCA = £250; at-risk women: control = £374, CBA = £329, PCA = £353	£121	Mean cost per woman with PND = £2419; Mean cost per woman without PND = £2027	Cost of EPDS (five minutes health visitor time) = £8, Cost of BDI (five minutes of health visitor time and licence fee) = £9; cost of structured psychological therapy (cost of treatment of PND) = £447; Cost of supportive care (cost of treatment of PND) = £414	£1,500	Psychological therapy = £ NZ$268; Social support = NZ$59; Combination therapy = NZ$561
Comparator cost	Total resources = £639	N/A		N/A			
Net cost (savings)	(£176)	N/A		£392.00			
Cost-effectiveness		N/A	ICER per month of PND avoided = £43.10		ICER per QALY for EPDS = £41,103; ICER for other strategies ranged from £23,195 to £814,623	Mean cost per QALY = £46,462 (£36,062 probabilistic sensitivity analysis)	ICER per QALY = NZ$3,461; ICER per additional case of PND detected = NZ$287, ICER per additional

From Systematic review	Morrell, 2016 (continued)						
							case of PND resolved = NZ$400
QALYs reported		N/A					
Cost per QALY		N/A				Mean cost per QALY = £46,462 (£36,062 probabilistic sensitivity analysis)	
Study quality	Good	Good	Good	Good	Good	Good	Good
Country	England	England	England	England	England	England	New Zealand
Original paper	Morrell, 2000	Morrell, 2009	Petrou, 2006	Petrou, 2002	Hewitt, 2009	Stevenson, 2010	Campbell, 2008

From Systematic review	Morrell, 2016 (continued)						
Extra notes	No QALYs or cost-effectiveness reported but comparator likely to be relatively easy to cost up and extra parameters to find as it is a UK study	Full details extracted in non-review data extraction	No QALYs but comparator likely to be relatively easy to cost up and extra parameters to find as it is a UK study	Not a specific intervention – looking at resource use of postnatal women with and without PND	No QALYs but comparator likely to be relatively easy to cost up and extra parameters to find as it is a UK study	Same results as provided by the synthesis of the Stevenson, 2010 review, extracted above (row 20)	No comparator costs but ICER per QALYs reported; based in New Zealand therefore potentially transferable to UK context.
Feasibility to model	Moderate	Strong	Strong	Poor	Strong	Strong	Moderate