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1 **Title page**

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3 **Cost-effectiveness of the Family Nurse Partnership (FNP) programme in England: evidence from the**
4 **Building Blocks trial**

5

6 **Byline**

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25 BC (Research Fellow, Health Economics) was responsible for conducting the economic evaluation and
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27 Economist and also conducted the economic evaluation. ES (Research Fellow, Health Economics), Dr GR
28 (Senior Research Fellow, Health Economics) and SR (Research Fellow, Health Economics) were also Health
29 Economists and contributed to the design and methodological approach for the health economics. JS (Senior
30 Clinical Researcher) was responsible for the delivery of the trial. Professor KH (Professor of Medical Statistics)
31 provided senior study design and statistical support to the trial. Professor MR (Director of Population Health
32 Trials) was the Chief Investigator of the trial and acts as overall guarantor for the study. Professor DT (Director
33 York Trials Unit) provided advice on the design and methodological approach for the trial as a whole and
34 oversaw the conduct of the economic analysis.

35

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41

42 **Declaration of interests**

43 We declare no competing interests

44

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47 Home visiting

48

49 **Cost-effectiveness of the Family Nurse Partnership (FNP) programme in England: evidence from the**
50 **Building Blocks trial**

51

52 **Abstract**

53

54 **Rational, aims and objectives:** The Family Nurse Partnership (FNP) is a licensed intensive home visiting
55 intervention developed in the USA. It has been provided in England by the Department of Health (DH) since
56 2006. The Building Blocks (BB) trial assessed the effectiveness and cost-effectiveness of FNP in England.

57

58 **Methods:** We performed a cost-utility analysis (NHS perspective) alongside the BB trial (over 2.5 years). The
59 analysis was conducted in accordance with NICE (National Institute for Health and Clinical Excellence)
60 reference case standards. Health-related quality of life was elicited from mothers using the EQ-5D-3L. Resource
61 use data were collected from self-reported questionnaires, Hospital Episode Statistics (HES), general
62 practitioner records and the central DH FNP database. Costs and quality-adjusted life years (QALYs) were
63 discounted at 3.5%. The base case analysis used an intention to treat approach on the imputed dataset using
64 multiple imputation (MI).

65

66 **Results:** The FNP intervention costs on average £1812 more per participant compared to usual care (95% CI -
67 £2700; £5744). Incremental adjusted mean QALYs are marginally higher for FNP (mean difference 0.0036,
68 95% CI -0.017; 0.025). The probability of FNP being cost-effective is less than 20% given the current NICE
69 willingness to pay threshold of £20 000 per additional QALY. The results were robust to sensitivity analyses.

70

71 **Conclusion:** Given the absence of significant benefits of FNP in terms of the primary outcomes of the trial and
72 only marginal maternal QALY gains, FNP does not represent a cost-effective intervention when compared with
73 existing services already offered to young pregnant women.

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80 **INTRODUCTION**

81

82 The Family Nurse Partnership (FNP) programme is an intensive preventive home visiting service with positive
83 results compared to usual services for mothers and babies both in the USA and the Netherlands [1-4]. It was
84 introduced for first time young mothers into NHS England by the Department of Health in 2006 [5-7]. In
85 October 2015 the FNP was transferred from NHS England to Local Authorities (LAs) and it is provided in
86 approximately 125 different LAs in England. The FNP programme was introduced to be an integral part of the
87 progressive universalism approach recommended in The Healthy Child Programme (HCP). The HCP is
88 delivered by the Family Nurse rather than by health visitors for women who enrol onto the programme.

89 Given the lack of evidence on the benefits of the FNP programme in England, the Building Blocks (BB) trial
90 was commissioned to evaluate the effectiveness and cost-effectiveness of the FNP intervention when delivered
91 in a comprehensive publicly funded health care setting. The BB protocol has been published 11 and all
92 amendments were reviewed and approved by the Wales NHS Research Ethics Committee (09/MRE09/08). The
93 details of the trial design, outcomes and clinical effectiveness are reported elsewhere 12, 13. The results from
94 the effectiveness analysis showed no statistically or clinically significant difference associated with FNP for any
95 of the four primary outcomes: smoking cessation (adjusted OR 0.90, 97.5% CI 0.64–1.2), birth weight
96 (adjusted mean difference 20.75 g, 97.5% CI –47.73 to 89.23), second pregnancies within two years (AOR
97 1.01, 0.77–1.33), or child A&E attendances and admissions to hospital (AOR 1.32, 97.5% CI 0.99–1.76,
98 $p=0.03$).

99 This paper reports on the cost-effectiveness analysis conducted alongside the Building Blocks (BB) trial. This
100 economic analysis also seeks to better understand a key example of an intervention that is routinely provided
101 without clear evidence on whether it represents good value for money for the health system compared to
102 comprehensive services, which in turn may help to guide disinvestment decisions that are unavoidable given the
103 financial constraints within a publicly funded health care system.

104

105 **METHODS**

106

107 **Overview**

108 Individual patient data from the BB trial were used to perform a cost-utility analysis measuring health-related
109 quality of life (HRQoL) in terms of quality-adjusted life years (QALYs). The analysis was from the NHS and

110 personal social services (PSS) perspective and expressed in UK pounds sterling (2013 GBP). Costs and QALYs
111 were discounted at a rate of 3.5% [8]. We used a regression approach on an intention-to-treat (ITT) basis. The
112 base case analysis was conducted on the dataset generated by multiple imputation by chained equations [9].
113 Sensitivity analysis included complete case (CC) analysis to test the impact of excluding participants with
114 missing data on the final results. All analyses and modelling were conducted in Stata 13.1 (StataCorp 2011, TX,
115 USA).

116 The BB trial was a pragmatic, non-blinded, parallel-group, randomised controlled trial (RCT) which recruited
117 within a community midwifery setting at 18 partnerships between LAs and primary and secondary care
118 organisations in England. The trial compared two arms; usual care (through primary-care public health and
119 social care services) plus FNP (FNP group) to usually provided health and social care alone (usual care group).
120 These groups were followed from early pregnancy (as soon as possible from the end of the first trimester) until
121 two years following childbirth. The trial recruited 1645 teenagers expecting their first baby, at less than 25
122 weeks gestation, between 16th June 2009 and 28th July 2010. The economic analysis is based on the 1618
123 participants that were assessed as eligible and did not withdraw consent for their data to be used. Mandatory
124 withdrawals (e.g. miscarriage, termination for fetal anomaly) were not included in the primary analysis
125 (FNP=26; usual care=24). Hence a total of 1568 (FNP=782; usual care=786) women were included in the base
126 case analysis.

127

128 **Health outcomes and quality-adjusted life-years**

129 The primary outcome measure was QALYs, based on the EQ-5D-3LTM (EuroQoL Group Rotterdam, The
130 Netherlands) reported by the women. The EQ-5D-3L has been used before in the UK setting within the context
131 of a pregnant population, for example in the economic evaluation conducted alongside the Early Labour Support
132 and Assessment (ELSA) trial [10]. The EQ-5D-3L health states were valued using a UK-based social tariff [11].
133 QALYs were calculated using the area under the curve method (AUC) [12] and were adjusted for baseline
134 utility[13].

135

136

137

138 **Resource use and costs**

139 Costs and health outcome data were collected via self-reported questionnaires at various time-points throughout
140 the trial: baseline, late pregnancy (34-36 weeks gestation), and 6, 12, 18 and 24 months postpartum. Baseline
141 and 24 month data were collected by face-to-face interview by a locally based researcher. Follow-up self-
142 reported data were collected via telephone by qualified telephone interviewers for the remainder of the time-
143 points. Data related to the use of hospital services were obtained from maternity notes, the Health and Social
144 Care Information Centre (HSCIC, Hospital Episode Statistics (HES)); and general practitioner (GP) visits were
145 obtained from GP records. The cost of the FNP intervention was based on the centralised FNP Information
146 System (IS) database run by Connecting for Health in Exeter (e.g. number of nurse visits, duration of visit,
147 number of telephone encounters). The unit costs used to estimate the total cost per participant in the trial are
148 presented in Table 1, sourced from the Personal Social Services Research Unit [14] and NHS reference costs
149 [15].

150 *Table 1*

151

152

153 **Handling missing data**

154 Complete case assessment excludes all participants with any missing or incomplete data. Excluding patients
155 with missing data leads to loss of power and biasing of the results due to a reduced sample size [16]. The
156 method we used to handle missing data was informed by the BB data. Incomplete data on costs and QALYs
157 were imputed using multiple imputation (MI) with chained equations and predictive mean matching; which
158 assumes that data are missing at random (MAR) [17-19]. The same set of covariates as in the clinical
159 effectiveness analysis was selected with stepwise regressions (e.g. site, smoking status, language and gestation).
160 Rubin's rules were used to combine point and variance estimates across imputed datasets, allowing the
161 estimation of difference in costs and QALYs between both groups [20].

162

163 **Base-case analysis**

164 The base-case analysis was conducted on the multiple imputed dataset, and followed an intention-to-treat (ITT)
165 approach. For the base-case analysis total costs constituted the cost of the FNP programme (nurse time used for

166 home based visits from the FNP nurse); GP and nurse visits (recorded in GP records), post-natal midwife and
167 health visitor visits (self-reported by mothers); and hospital activity (HES records for inpatient admission,
168 outpatient visits and A&E services).

169 The cost-effectiveness of the FNP programme was evaluated by comparing the mean differences in costs and
170 effects in the two groups, using conventional rules and estimating the incremental cost-effectiveness ratio
171 (ICER) as appropriate [21]. The mean differences in costs and QALYs were estimated using seemingly
172 unrelated regression (SUR) [22], and their 95% confidence intervals (CI) estimated using bias corrected and
173 accelerated (BCA) bootstrap methods. Non parametric bootstrapping [23] was used to transform the uncertainty
174 around the trial estimates into the probability that the FNP intervention is cost-effective for thresholds used by
175 the National Institute for Health and Care Excellence (NICE) of £20 000 and £30 000 per QALY gained [8],
176 with cost-effectiveness acceptability curves (CEACs) used.

177

178 **Sensitivity analyses**

179 Sensitivity analyses in the base case were conducted to test the robustness of the results using five scenarios:
180 complete case (CC) analysis according to ITT; MI removing midwife visits reported by mothers allocated to
181 FNP (i.e. to avoid double counting in case those visits were already included in the FNP IS dataset); MI
182 including the limited data available for mothers that withdrew due to mandatory withdrawals (i.e if FNP were to
183 be implemented, costs related to mandatory withdrawals would be covered by the NHS); MI using self-report
184 data (i.e including resource use exclusively related to mothers, hence excluding resource use related to babies);
185 and MI halving the cost for the FNP intervention.

186

187 **RESULTS**

188

189 The results from the effectiveness analysis showed no statistically or clinically significant difference associated
190 with FNP for any of the four primary outcomes: smoking cessation (adjusted OR 0.90, 97.5% CI 0.64–1.2),
191 birth weight (adjusted mean difference 20.75 g, 97.5% CI –47.73 to 89.23), second pregnancies within two
192 years (AOR 1.01, 0.77–1.33), or child A&E attendances and admissions to hospital (AOR 1.32, 97.5% CI
193 0.99–1.76, p=0.03).

194 **Health outcomes and quality-adjusted life-years**

195 Table 2 presents the proportion of participants with complete EQ-5D data. A small number of trial participants
196 (n=10) allocated to the control arm were erroneously enrolled into FNP. Following the ITT principle they were
197 analysed in their allocated arm regardless. Data were considered missing or incomplete when women did not
198 complete the EQ-5D or provided a partially completed questionnaire. Two points would support the MAR
199 assumption used as the basis for the base-case analysis: (i) the missing data followed an intermittent pattern (e.g.
200 in both groups, more women were observed at 12 months than at six months, and the same pattern is observed at
201 18 and 24 months) hence complete case assessment would be, as a minimum, inefficient because it would
202 discard observed data from individuals with some missing outcomes; and (ii) the BB data showed that
203 participants with lower EQ-5D at baseline were more likely to have missing QALY data, which in turn suggests
204 that the data are unlikely to be MCAR.

205 Participants in the FNP group started from a lower baseline HRQoL was a mean (SD) of 0.90 (0.005) (FNP)
206 versus 0.91 (0.005) (usual care). The EQ-5D-3L scores did not differ significantly between groups at each
207 follow-up (Table 3). The difference in mean EQ-5D-3L scores at 2 years (FNP – usual care) when controlling
208 for baseline utility (for available cases: 320 FNP versus 265 usual care) was -0.008 (95% CI -0.023 to 0.008).

209 **Table 2**

210

211 Despite any difference seen in the EQ-5D-3L across the groups, this translates to very little difference in utilities
212 (Figure I) and QALYs between the FNP and usual care groups.

213 **Figure 1**

214

215 **Resource use and costs**

216 There were no clear differences in resource use across the two groups (Table 3), though A&E attendances for
217 mothers and babies were somewhat higher in the FNP group. Babies in the usual care group had on average
218 longer inpatient length of stay in hospital than those babies whose mothers were randomised to the FNP
219 intervention.

220 **Table 3**

221

222 Cost differences were very small across groups (Table 4). Costs associated with the delivery of the FNP
223 intervention and the inpatient stays in hospital for babies were the major cost drivers for the cost-effectiveness.
224 Using the principle of ITT and assigning a cost of £0.00 to women who did not receive the intervention, the
225 average cost of nurse time for FNP visits was £3845 (SD £77), and £33 (SD £2) for FNP phone calls; however,
226 considering only the 719 women who received the intervention, the average cost of nurse time was £4,270 (SD
227 £1,855) per woman. If we assume that on average women were recruited at 18 weeks gestation then, the annual
228 cost of nurse time for the FNP home visits is £1,762 per women.

229 **Table 4**

230

231 **Cost-effectiveness analysis**

232 The incremental analysis (Table 5), when adjusting for all covariates (baseline utility, site, smoking status,
233 language and gestation), showed the FNP intervention costs on average £1811 more per participant when
234 compared with usual care (95% CI -£2814; £5547). Incremental mean QALYs when adjusted for baseline utility
235 are marginally higher for FNP (mean difference 0.0036, 95% CI -0.017; 0.025). This difference is even lower
236 when adjusted for the remaining covariates (mean difference 0.0030, 95% CI -0.017; 0.027). The Net Monetary
237 Benefit associated with the FNP intervention is negative (-£1750.57), indicating that the resources displaced
238 would be greater than the benefit gained with the delivery of the FNP intervention. The probability of the FNP
239 intervention being cost-effective was less than 20% given the NICE currently accepted threshold of £20 000 to
240 £30 000 per additional QALY (Figure 2).

241 **Table 5**

242

243 **Figure 2**

244

245 The sensitivity analyses (Table 5) showed that the conclusions from the base case analysis were robust to all
246 scenarios, FNP remained a non-cost-effective intervention, with the ICERs much higher than the thresholds that
247 NICE normally consider for reimbursement decisions. Because it was felt that the cost of the intervention is the
248 main cost driver for the analysis, the cost of the FNP intervention was halved to assess the effect on the cost-

249 effectiveness conclusions. The mean difference in costs per participant is reduced to £360 (95% CI £-3680 to
250 £4352); the gain in QALYs is still very marginal at 0.0047 (95% CI -0.013; 0.022). The results continue to be
251 uncertain and the probability of FNP being cost-effective less than 50%. The complete case analysis shows that
252 the FNP intervention cost, on average, £4549 more per woman when compared with usual care (95% CI £3175
253 to £5922). Participants allocated to the FNP intervention accrued fewer QALYs than those for usual Care (-
254 0.007, 95% CI -0.042 to 0.027). Therefore the results of the complete case analysis indicate FNP was dominated
255 by usual care.

256

257 **DISCUSSION**

258

259 This economic evaluation provides evidence that FNP is more costly than usual care and provides only a very
260 small QALY gain. Similarly the analysis of uncertainty confirmed that it is unlikely that FNP represents an
261 efficient intervention even if the cost was substantially reduced. The base case results indicate that the
262 probability of FNP being cost-effective is 17%, with the results being robust to sensitivity analyses.

263 There is evidence of positive results of the FNP intervention in the US, a context where mothers are not able to
264 access many statutory supportive health and social services, and maternity community based services. In
265 contrast, pregnant women in the UK can access a wide provision of maternal care including community care
266 family doctors, midwives and public health nurses, and as we observed in our trial sites, specialist teenage
267 pregnancy midwives as well. It is worth it to note that the differences between the US and UK health systems
268 can explain the lack of clinical or quality-of-life benefits for those women who receive the FNP programme as a
269 public service offered in the UK. The Building Blocks trial is the first UK-based trial of FNP, therefore this
270 analysis represents the most up-to-date estimate of the cost-effectiveness of FNP when delivered in a universal,
271 publicly funded, health care setting.

272 There are two noteworthy limitations of this study. The first limitation relates to the level of missing data.
273 Despite steps to minimise missing data (e.g. computer assisted telephone interviews), the number of EQ-5D
274 questionnaires completed for each data collection wave decreased over time. This is a common problem in trial-
275 based economic evaluations that is amplified where there are frequent assessments, as in here. It is worth noting
276 that the use of HES data helped to minimise considerably the problem of incomplete data thus enabling more
277 accurate estimates of hospital costs. The second limitation relates to the duration of the BB trial. In our trial we
278 are able to assess programme cost-effectiveness in the short-term only and we recognise that for preventative

279 programmes benefits may be expected to accrue over a longer time period and in domains of child development.
280 Reported analyses of programme cost-effectiveness in the US have highlighted the advantage for high-risk
281 families in particular over longer but variable periods of time. The Social Research Unit at Dartington, and
282 Aldaba Limited conducted a cost-benefit analysis for FNP in the UK using a modelling approach which
283 describes the longer-term savings by the FNP programme, indicating that key savings being related to higher
284 earnings and higher attainment test scores [24] There have been some shortcomings identified with the
285 economics analyses previously reported [25], for example some double counting of non-independent outcomes.
286 In one meta-analytic review the cost savings for the programme were greatest for outcomes related to the mother
287 (e.g. reduced crime, higher earnings, reduction in welfare) rather than the child [26]. Positive programme
288 outcomes identified the trial include maternally reported child language development. This is of potential
289 longer-term importance but requires further evaluation over the medium term to first verify with objective
290 ratings and second to determine whether any short-term advantage is continued to improvements in later
291 outcomes such as school readiness. These objectives are currently being assessed in a linked study.

292 Besides it could be argued that we only look at QoL for the women and not the children. The EuroQol Group
293 has developed a child-friendly EQ-5D version (EQ-5D-Y)[27], however the age of 8 is the lower age limit for
294 which the instrument is valid hence the EQ-5D-Y was not applicable for the children in the BB trial. Regarding
295 mothers, the EQ-5D-3L did detect differences in scores between stages of pregnancy (e.g. women reported more
296 problems in pain/discomfort and mobility at late pregnancy than any other follow-up point); which shows that
297 this instrument can capture small yet important changes which are important to reflect the impact of the
298 intervention on health. Similarly it could be debated that the QALY instrument lacks sensitivity for measuring
299 the impact of FNP in health. Nonetheless within the UK the access to a new intervention has to be justified by
300 the health gain it provides compared with usual care, where the added benefit is typically expressed in QALYs.
301 In order to overcome the limitation of the QALY approach, this study was complemented with (i) a cost-
302 consequence analysis (Policy Research Programme Project April 2015); and (ii) a discrete choice experiment
303 that examined the preferences of the general population for the outcomes of the trial.

304 There are two main points that this study adds. From a research perspective, this study emphasises the need to
305 conduct trials and to evaluate the effectiveness and cost-effectiveness of policy interventions before they are
306 implemented. From a policy making perspective this study can contribute to everyday decision making
307 regarding which services to offer to young pregnant women. Our findings provide strong evidence to suggest

308 that the delivery of FNP is not better for young mothers or their babies than comprehensive services in the short
309 term, while costing more. There is currently evidence supporting other cost-effective public interventions among
310 pregnant women aiming to address some of the primary outcomes of the BB trial, with a positive influence at a
311 relatively low cost, and maybe cost saving (e.g. smoking cessation) (Ruger et al. 2008; Tappin et al. 2015).

312 In England and Wales, there were 23 948 live births to women aged under 20 during 2015 (Statistics 2015)). If
313 we assume that around 50% of these women were offered an FNP place then the annual cost saving in England
314 from removing the FNP programme would be around £21 million.

315

316 **CONCLUSION**

317 The Building Blocks trial is the first UK-based trial of FNP. As discussed, the FNP intervention did not deliver
318 significant benefits on any of the primary outcomes and only limited benefits on a small number of secondary
319 outcomes where the risk of a chance finding is greater. Thus, taken together with the effectiveness findings, the
320 results of this economic evaluation suggest that FNP does not represent a cost-effective intervention when
321 adding FNP to existing services already offered to young pregnant women in England. However, it is important
322 to note that these results are based on the two year trial only and cannot account for any longitudinal outcomes
323 that may emerge at a later stage. Hence, at this time, we cannot recommend the continuation of FNP delivery
324 and it may be the case that displacing the resources currently used in the FNP and investing in alternative
325 interventions could potentially result in greater gains in child health, development and family economic stability
326 for this population.

327

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369 **References**

- 370 1. Kitzman H, Olds DL, Henderson CR, et al. Effect of prenatal and infancy home visitation by nurses
 371 on pregnancy outcomes, childhood injuries, and repeated childbearing: a randomized
 372 controlled trial. *JAMA* 1997;**278**(8):644-52
- 373 2. Mejdoubi J, van den Heijkant SC, van Leerdam FJ, Crone M, Crijnen A, HiraSing RA. Effects of nurse
 374 home visitation on cigarette smoking, pregnancy outcomes and breastfeeding: A
 375 randomized controlled trial. *Midwifery* 2014;**30**(6):688-95
- 376 3. Olds DL, Henderson CR, Tatelbaum R, Chamberlin R. Improving the delivery of prenatal care and
 377 outcomes of pregnancy: a randomized trial of nurse home visitation. *Pediatrics*
 378 1986;**77**(1):16-28
- 379 4. Olds DL, Robinson J, O'Brien R, et al. Home visiting by paraprofessionals and by nurses: a
 380 randomized, controlled trial. *Pediatrics* 2002;**110**(3):486-96
- 381 5. Barnes J. Nurse-family partnership programme: first year pilot site implementation in England:
 382 pregnancy and the post-partum period. 2008
- 383 6. Barnes J. Nurse-family partnership programme second year pilot sites implementation in England
 384 the infancy period. 2009
- 385 7. Barnes J, Ball M, Meadows P, et al. The Family-Nurse Partnership programme in England: Wave 1
 386 implementation in toddlerhood and a comparison between Waves 1 and 2a of
 387 implementation in pregnancy and infancy. 2011
- 388 8. National Institute for Health and Care Excellence. Guide to the methods of technology appraisal.
 389 London: NICE, 2013.
- 390 9. Faria R, Gomes M, Epstein D, White IR. A guide to handling missing data in cost-effectiveness
 391 analysis conducted within randomised controlled trials. *PharmacoEconomics*
 392 2014;**32**(12):1157-70
- 393 10. Spiby H. Improving care at the primary/secondary interface: a trial of community-based support
 394 in early labour. The ELSA trial. Report for the National Co-ordinating Centre for NHS Service
 395 Delivery and Organisation R&D (NCCSDO) 2008
- 396 11. Dolan P, Gudex C, Kind P, Williams A. A social tariff for Euroqol: Results from a UK general
 397 population survey. York: Centre for Health Economics Discussion Paper. Sep; 138, 1995.
- 398 12. Billingham L, Abrams KR, Jones DR. Methods for the analysis of quality-of-life and survival data in
 399 health technology assessment. *Health technology assessment (Winchester, England)*
 400 1998;**3**(10):1-152
- 401 13. Manca A, Hawkins N, Sculpher MJ. Estimating mean QALYs in trial-based cost-effectiveness
 402 analysis: the importance of controlling for baseline utility. *Health economics* 2005;**14**(5):487-
 403 96
- 404 14. Curtis L. Unit Costs of Health and Social Care 2013. University of Kent: Personal Social Services
 405 Research Unit, 2013.
- 406 15. Department of Health. NHS Reference Costs 2012/13. .
 407 <https://www.gov.uk/government/publications/nhs-reference-costs-2012-to-2013>, 2013.
- 408 16. Little RJ, Rubin DB. The analysis of social science data with missing values. *Sociological Methods*
 409 & Research 1989;**18**(2-3):292-326
- 410 17. Manca A, Palmer S. Handling missing data in patient-level cost-effectiveness analysis alongside
 411 randomised clinical trials. *Applied health economics and health policy* 2005;**4**(2):65-75
- 412 18. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and
 413 guidance for practice. *Stat. Med.* 2011;**30**(4):377-99
- 414 19. Carlin JB, Galati JC, Royston P. A new framework for managing and analyzing multiply imputed
 415 data in Stata. *Stata Journal* 2008;**8**(1):49-67
- 416 20. Rubin DB. *Multiple imputation for nonresponse in surveys*: John Wiley & Sons, 2004.
- 417 21. Johannesson M, Weinstein MC. On the decision rules of cost-effectiveness analysis. *J. Health*
 418 *Econ.* 1993;**12**(4):459-67

419 22. Manca A, Hawkins N, Sculpher MJ. Estimating mean QALYs in trial-based cost-effectiveness
420 analysis: the importance of controlling for baseline utility. *Health Econ.* 2005;**14**(5):487-96
421 doi: 10.1002/hec.944[published Online First: Epub Date]].

422 23. Efron B, Tibshirani RJ. *An introduction to the bootstrap*: CRC press, 1994.

423 24. Social Research Unit D. <http://investinginchildren.eu/interventions/family-nurse-partnership>.

424 25. Stamuli E, Richardson G, Duffy S, Robling M, Hood K. Systematic review of the economic
425 evidence on home visitation programmes for vulnerable pregnant women. *Br. Med. Bull.*
426 2015;**115**(1):19-44

427 26. Aos S, Lieb R, Mayfield J, Miller M, Pennucci A. Benefits and costs of prevention and early
428 intervention programs for youth: Olympia: Washington State Institute for Public Policy,
429 2004.

430 27. Wille N, Badia X, Bonsel G, et al. Development of the EQ-5D-Y: a child-friendly version of the EQ-
431 5D. *Qual. Life Res.* 2010;**19**(6):875-86

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Table 1 Unit costs used for costing primary care and community services

Item	Unit	Cost	Reference	Notes
GP	Per Surgery consultation lasting 11.7 min	£45	Unit Costs of Health and Social Care 2013	Including direct care staff costs & qualifications
	Per out of surgery (home visiting) lasting 23.4 min	£114		
GP Nurse	Per Surgery consultation lasting 15.5 minutes	£13.4	Unit Costs of Health and Social Care 2013	Assume same duration than GP home visit
	Per home visiting lasting 23.4 min	£27.3		
Midwife	Antenatal visit (Community)	£51	NHS reference costs 2012/2013 (NHS trusts and NHS foundation trusts)	Community Health Services – Health Visiting and Midwifery
	Postnatal visit (Community)	£68		
	Home visit	£70	Unit Costs of Health and Social Care 2013	
	Midwife episode	£65		
Health visitor	Per hour	£49	Unit Costs of Health and Social Care 2010	Assume same duration than GP home visits
	Per hour of home visiting	£71		
Counsellor	Surgery consultation	£58	Unit Costs of Health and Social Care 2013	
Mental health	Per hour per team member	£36	Unit Costs of Health and Social Care 2013	Community mental health team for adults with mental health problems.
Crisis Resolution team	Per hour per team member	£37	Unit Costs of Health and Social Care 2013	
Support worker	Per hour	£22	Unit Costs of Health and Social Care 2013	
Social worker	Per hour	£79	Unit Costs of Health and Social Care 2013	
Physiotherapist	Surgery session per hour	£34	Unit Costs of Health and Social Care 2013	
	Hospital session per hour	£36		
FNP Supervisor Nurse	Clinic or phone visit per minute	£1.34	Unit Costs of Health and Social Care 2013	Qualified nursing, midwifery & health visiting staff by Agenda for change band 8a, NHS England.
	Home visit per minute	£1.62		
FNP Nurse	Clinic or phone visit per minute	£1.17	Unit Costs of Health and Social Care 2013	Qualified nursing, midwifery & health visiting staff by Agenda for change band 7, NHS England.
	Home visit per minute	£1.41		

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457 **Table 2 Complete cases**

	Complete Cases	
	FNP (n=808)	Usual Care (n=810)
EQ-5D Baseline	808 (100%)	807 (99%)
EQ-5D 34-36 weeks	614 (76%)	616 (76%)
EQ-5D 6 months	507 (63%)	469 (58%)
EQ-5D 12 months	510 (63%)	480 (59%)
EQ-5D 18 months	499 (62%)	465 (57%)
EQ-5D 24 months	583 (72%)	537 (66%)
EQ-5D all assessments	349 (41%)	265 (34%)
GP records	480 (61%)	471 (60%)
Hospital data (HES records)	808 (100%)	810 (100%)
Complete-Case dataset ^	217 (28%)	186 (24%)

458 ^ The complete dataset used for the base-case analysis comprised all mothers whose all six EQ-5D-3L
 459 assessments and all costs (GP records, health visitor/midwife visits and hospital attendances) were available.

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Table 3 Mothers and babies average resource use per arm of the trial from baseline up to two years following child birth

	FNP (n=782)					Usual Care (n=786)				
	n	Mean (SD)	Min, Max	Median	Missing	n	Mean (SD)	Min; Max	Median	Missing
GP surgery visits for mothers	471	9.55 (8.40)	0; 48	7	39.76%	480	8.49 (7.81)	0; 48	7	38.93%
GP home visits for mothers	471	0.22 (0.84)	0; 9	0	39.76%	480	0.21 (0.76)	0; 8	0	38.93%
Nurse surgery visits for mothers	471	2.14 (3.61)	0; 36	1	39.76%	480	2.22(3.01)	0; 20	1	38.93%
Community Midwife visits	459	10.40 (5.34)	0;41	10	41.30%	422	10.68 (5.25)	0; 41	10	46.31%
Community Health visitor visits	363	8.60 (13.74)	0; 68	0	53.58%	321	16.25 (12.15)	0;73	13	59.16%
Community Counsellor visits	612	0.29 (1.23)	0;12	0	21.73%	614	0.32 (1.64)	0;20	0	21.88%
Inpatient Length of Stay mothers	782	3.98 (6.35)	0; 99	3	0%	786	4.09 (6.39)	0;110	2	0%
Day case admissions for mothers	782	3.53 (5.19)	0; 60	2	0%	786	3.57 (5.48)	0;77	2	0%
Outpatient visits for mothers	782	8.61 (8.05)	0; 74	7	0%	786	8.55 (8.05)	0; 70	6.5	0%
A&E attendances for mothers	782	4.54 (2.43)	0; 36	1	0%	786	1.58 (2.55)	0; 29	1	0%
GP surgery visits for babies	471	8.17 (7.10)	0; 70	7	39.76%	480	7.60 (6.20)	0; 51	7	38.93%
GP home visits for babies	471	0.29 (1.25)	0; 17	0	39.76%	480	0.29 (1.61)	0; 20	0	38.93%
Nurse surgery visits for babies	471	0.88 (2.17)	0; 22	0	39.76%	480	0.90 (2.05)	0; 18	0	38.93%
Inpatient length of stay for babies	724	2.82 (21.32)	445 ;0	0	0%	757	3.10 (25.29)	0; 466	0	0%
Day case admissions for babies	724	1.74 (3.42)	0;34	0	0%	757	1.79 (3.31)	0; 32	0	0%
Outpatient visits for babies	724	1.82 (5.29)	0;69	0	0%	757	2.08 (7.03)	0; 135	0	0%
A&E attendances for babies	724	2.58 (3.24)	0; 30	2	0%	757	2.21 (2.53)	0; 15	1	0%
FNP visits/encounters	709	39.28 (15.19)	1; 88	41	10%	10	0.45 (4.26)	0; 53	0	NA
FNP phone calls	709	6.29 (5.34)	2; 31	4	10%	10	0	0	0	NA

SD, standard deviation

Table 4 Costs associated with all available cases: mean and standard deviation (in brackets). Costs discounted from year 2 at 3.5% according to ITT. Mean incremental costs and 95% CI estimated using OLS regression

	Mean cost £ (SD)		Difference (FNP - Usual Care) (95% CI)
	FNP	Usual Care	
GP surgery visits for mothers	429.95 (17.49)	382.35 (16.20)	47.60 (0.82; 94.37)
GP home visits for mothers	25.82 (4.42)	24.92 (4.18)	0.89 (-11.96; 12.84)
Nurse surgery visits for mothers	21.17 (1.69)	22.63 (1.41)	-0.83 (-5.17; 3.50)
Community Midwife visits	15.51 (332.38)	15.29 (314.19)	-20.96 (-63.82; 21.89)
Community Health visitor visits	135.67 (11.34)	217.78 (10.25)	-82.10 (-112.42; -51.78)
Community Counsellor visits	16.86 (71.56)	19.08 (94.79)	-11.62; 7.20)
Inpatient length of stay mothers	6354.57 (8460.72)	6661.17 (9679.04)	-306.59 (-1193.20; 580.00)
Day case admissions for mothers	775.22 (1041.62)	781.72 (1216.929)	-6.50 (-116.98; 103.96)
Outpatient visits for mothers	889.49 (903.30)	875.63 (918.99)	13.85 (-75.01; 102.71)
A&E attendances for mothers	167.06 (277.82)	172.79 (289.34)	-5.72 (-33.39; 21.93)
GP surgery visits for babies	367.74 (14.92)	342.37 (12.80)	25.36 (-13.13; 63.86)
GP home visits for babies	33.13 (6.64)	32.64 (8.38)	0.49 (-20.57; 21.56)
Nurse surgery visits for babies	8.96 (1.03)	9.21 (0.95)	-0.25 (-3.00; 2.50)
Inpatient length of stay for babies	3773.35 (25939.83)	4882.99 (50019.88)	-1109.634 (-5198.32979.6)
Day case admissions for babies	142.02 (702.62)	145.17 (615.10)	-3.15 (-70.38; 64.08)
Outpatient visits for babies	290.96 (983.72)	272.92 (842.08)	-18.03 (-111.56; 75.49)
A&E attendances for babies	293.12 (370.60)	254.93 (298.36)	38.16 (3.94; 72.38)
FNP visit/encounters	3845.32 (76.69)	47.27 (16.08)	3798.05 (3644.70; 3951.4)
FNP phone calls	33.27 (2.84)	0 (0)	33.27 (27.70; 38.83)

SD, standard deviation

Table 5 Summary of incremental analysis (ITT), cost-effectiveness results and uncertainty for the base case (highlighted) and sensitivity analyses

Analysis	Difference in costs*	Difference in QALYs*	ICER for FNP intervention (£ per QALY)	Probability FNP Cost-effective† £20 000/QALY
Base case (MI)	1812 (-2814; 5447)	0.0030 (-0.01; 0.02)	Above £100,000 per QALY	17%
Sensitivity i (CC)	4549 (3175; 5922)	-0.007 (-0.042; 0.027)	FNP dominated	0%
Sensitivity ii	1933 (-2641; 5654)	0.005 (-0.017; 0.027)	Above £100,000 per QALY	16%
Sensitivity iii	2061 (-1949; 6072)	0.005 (-0.014; 0.025)	Above £100,000 per QALY	17%
Sensitivity iv	3272 (2288; 4295)	0.004 (-0.018; 0.025)	Above £100,000 per QALY	0%
Sensitivity v	360 (-3680; 4352)	0.005 (-0.013; 0.022)	£73,924 per QALY	45%