The equity impact of participatory women’s groups to reduce neonatal mortality in India: secondary analysis of a cluster-randomised trial

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Progress towards the Millennium Development Goals (MDGs) has been uneven. Inequalities in child health are large and effective interventions rarely reach the most in need. Little is known about how to reduce these inequalities. We describe and explain the equity impact of a women’s group intervention in India that strongly reduced the neonatal mortality rate (NMR) in a cluster-randomised trial. We conducted secondary analyses of the trial data, obtained through prospective surveillance of a population of 228,186. The intervention effects were estimated separately, through random effects logistic regression, for the most and less socio-economically marginalised groups. Among the most marginalised, the NMR was 59% lower in intervention than in control clusters in years 2 and 3 (70%, year 3); among the less marginalised, the NMR was 36% lower (35%, year 3). The intervention effect was stronger among the most than among the less marginalised (P-value for difference = 0.028, years 2-3; P-value for difference = 0.009, year 3). The stronger effect was concentrated in winter, particularly for early NMR. There was no effect on the use of health-care services in either group, and improvements in home care were comparable. Participatory community interventions can substantially reduce socio-economic inequalities in neonatal mortality and contribute to an equitable achievement of the unfinished MDG agenda.

Introduction

Progress towards the Millennium Development Goals (MDGs) has been uneven.1–5 Inequalities in maternal and child health are especially large.6,7 Few of the poorest women in developing countries receive professional care during delivery, whereas most wealthier women do.8 The link between socio-economic disadvantage and health disadvantage has serious consequences: one third of global childhood deaths are attributable to inequalities in socio-economic mortality within countries.9 Effective interventions are known,10,11 but rarely reach those who need them most.12–19 Even ‘basic’ interventions that are thought to favour the poor, such as oral rehydration therapy and immunisation, tend to predominantly reach those who are more economically comfortable.12–14 Little is known about how to reduce socio-economic inequalities in
mortality and how to support an equitable utilization of interventions. Reducing neonatal mortality is becoming increasingly important to achieve MDG4 (‘reduce child mortality’) as its relative contribution to under-5 mortality rises. Although policy attention to newborn health has until recently been scant, new initiatives for this have begun to emerge. Community-based interventions, including home-based newborn care by community health workers and participatory women’s groups, play an important role in strategies to improve neonatal survival, especially in South Asia, where about 50% of births happen at home without professional care. Little is known about the equity impact of community-based health interventions. Although there are some accounts of reductions in inequality in health-related behavior, there are also indications that they may reinforce existing social hierarchies and there is no evidence about their effect on equity with respect to neonatal mortality.

A cluster-randomised controlled trial of a participatory women’s group intervention in India, the ‘Ekjut trial’, provides a unique opportunity to assess the effect of community interventions on equity through the use of a ‘gold standard’ design. India is the site of a quarter of global neonatal deaths and inequalities in mortality in the country are large. The Ekjut trial showed a strong effect of women’s groups on the neonatal mortality rate (NMR) in the population in whom the trial was conducted (a 49% decline in years 2 and 3 of the intervention). Although the trial was conducted in deprived rural areas, these communities are, as in most low- and middle-income countries, not homogenous. Literacy, economic status, land ownership, and tribal status/caste are important dimensions of social stratification. Our study aimed to describe and explain the equity impact of the Ekjut intervention. In particular, we examined: (i) whether the strong effects of the intervention on NMR were also observed among lower socio-economic groups; and (ii) whether there were differences in the effect of the intervention on mortality in the most and less socio-economically marginalised groups. We also explored potential explanations for differences in the effect of the intervention.

Methods
Setting
The study areas were located in three contiguous districts in Orissa and Jharkhand, two of the poorest Indian states, with large tribal (adivasi) populations, of which the majority are classified as Scheduled Tribes under the Indian constitution. Within these districts, 36 poor clusters with a predominantly tribal population were identified and randomly assigned to intervention or control. The intervention arm of the trial received an intervention with participatory women’s groups. The participatory groups met on a monthly basis, guided by a facilitator, throughout the 3-year study period. They used a participatory learning and action cycle, in which maternal and newborn health problems were identified and prioritized. Strategies to address these problems were developed, implemented, and evaluated, with the support of the entire community. The trial has been described elsewhere.

Surveillance
All births and neonatal deaths in the study areas were recorded through prospective surveillance. Local key informants, covering about 200–250 households, identified all births, birth outcomes, and deaths to women of reproductive age on an ongoing basis. Every month, the informants reported the identified births and deaths to full-time salaried interviewers, who then verified all of the reported information. At about 6 weeks post-partum, the interviewer administered a questionnaire to the mother. The interview covered socio-economic and socio-demographic background characteristics; home-care practices; use of health-care services during pregnancy, delivery, and the neonatal period; and condition of the mother and baby, including the reported size at birth and gestational age of the baby. In the event of a stillbirth, neonatal death, or maternal death, a verbal autopsy was done with the mother or a close caregiver. The verbal autopsy consisted of a standard questionnaire that also included free text for elaboration on the sequence of events before death. Clinicians assigned cause of death on the basis of the information provided by the verbal autopsy. The surveillance system has been extensively tested in trials over the past 10 years, and has been described in detail elsewhere. We included all live births (singleton and twins/triplets) among residents of the study area during the 9-month baseline and 3-year study periods. Mothers who had permanently emigrated from the study areas were excluded from the final study population. Loss to follow-up from migration or refusal of interview was low (<2%).

Primary outcome
We evaluated the equity impact of the intervention in terms of NMR (number of deaths during the first 28 days of life per 1000 live births; the primary outcome of the original trial) among lower and higher socio-economic groups. The trial paper reported the strongest impact on NMR as occurring in the last two study years, probably because of a lag-time in effect of 9–12 months. Because we were interested in how these strong effects were distributed across socio-economic groups, and because the statistical power requirements of equity impact analyses are higher than for the testing of overall effects, we performed our main analyses on years 2 and 3 combined.
**Socio-economic groups**

The equity impact of the intervention was examined for those dimensions of social stratification that are important in the rural Indian context of the study: caste/tribal status (comparing Scheduled Tribes and Scheduled Castes, both of which are historically disadvantaged and recognised as such by the Indian constitution, with the rest of the study population), land ownership, literacy, and asset ownership. In conjunction with local collaborators, we constructed lower and higher socio-economic categories that were meaningful in the context of the study. Asset ownership was measured with an index constructed using principal component analysis (PCA) which was applied to all durable consumer items in the questionnaire (electricity generator, battery, tape, electric fan, television, refrigerator, motor, radio, bicycle). PCA was done on a data set including all years of the intervention. Further analysis showed that the poorest category owned nothing or only a bicycle. Because the study areas were socio-economically deprived, the distribution of socio-economic position was skewed, with 60–80% of live births occurring among women in the lowest categories (Table 1). Although it is important to examine whether the intervention benefited not only the ‘elite’ 20–40% of the study population, substantial effects of intervention are expected in lower socio-economic groups, given the strong overall effects of the intervention and that most of the population belongs to these groups. We therefore went one step further and examined whether the intervention benefited the most socio-economically marginalised persons in the population, consisting of those who were illiterate, and very poor, and had little or no land, and belonged to Schedule Tribes or Scheduled Castes, thereby explicitly considering the multi-dimensional aspect of social stratification in the context of the study. About 30% of the study population belong to the most socio-economically marginalised groups, with the remainder belonging to those less marginalised.

**Analyses**

First, we obtained cluster-adjusted estimates of the NMR for the total population and for each socio-economic category, year, and study arm (as presented in Table 2), using random-effects logistic regression (Equation 1). Separate models were made for each dimension of social stratification. For individual j in cluster i, the logarithm of the odds of neonatal death (NND) is:

\[
\log \text{odds NND} = \alpha + \beta_1(\text{YearL}_i) + \beta_2(\text{YearL}_c) + \beta_3(\text{YearH}_i) + \beta_4(\text{YearH}_c) + \beta_5(\text{Contint}) + \beta_6(\text{SEP}) + \beta_7(\text{Contint}^*\text{SEP}) + \beta_8(\text{STRATA}) + u_i + \epsilon_j
\]  

where YearL, YearL, YearH, and YearH are the differences in NMR between consecutive intervention years (with year as categorical variable) and the baseline year for the low (L) and high (H) socio-economic groups in the intervention and control arms, respectively. Contint represents the difference in NMR between the intervention- and control-arms at baseline; SEP the effect of socio-economic position at baseline in the control arm; Contint*SEP the difference in effect of socio-economic position between the intervention and control arms; STRATA the adjustment for the stratified sampling design; and u the random-effect term, i.e. the difference for each cluster i vs. the baseline \( \alpha \).

We then estimated linear trends in NMR between baseline and year 3 for each socio-economic category and study arm by defining year as the interval variable in Equation 1. Next, we replicated the trial analysis by comparing the NMR in intervention and control areas for the total study population for years 2 and 3 combined, using a random-effects logistic regression model. We expanded this using Equation 2 to estimate the effects of intervention for lower and higher socio-economic groups separately (Table 3). For individual j in cluster i:

\[
\log \text{odds NND} = \alpha + \beta_1(\text{INT}_L) + \beta_2(\text{INT}_H) + \beta_3(\text{SEP}) + \beta_4(\text{STRATA}) + u_i + \epsilon_j
\]  

where INT_L and INT_H are the differences between the intervention and control arms among low- and high socio-economic groups respectively, and SEP is the effect of low socio-economic position in the control arm.

Lastly, we tested the difference in the effect of intervention in lower vs. higher socio-economic groups, using a different parameterisation of Equation 2 (Equation 3; see also Table 3).

\[
\log \text{odds NND} = \alpha + \beta_1(\text{INT}_H) + \beta_2(\text{SEP}) + \beta_3(\text{SEP}^*\text{INT}_H) + \beta_4(\text{STRATA}) + u_i + \epsilon_j
\]  

where SEP*INT_H is the difference in the intervention effect between lower and higher socio-economic groups.

To explain our findings, we explored whether differences in effect between the most and less marginalised groups were concentrated in the early (days 1–7) or late (days 8–28) neonatal period. Furthermore, given the strong seasonality in NMR in our population, we examined whether differences in effect were seasonal. Additionally, using the equations given above, we explored whether the use of health care (particularly ante-natal, delivery, and post-natal care, and medical care-seeking in case of an infant illness), home-care practices (particularly practices related to prematurity, hypothermia, and infections), and attendance at the women’s groups would explain our findings.

We examined whether baseline differences could explain our findings using Equation 1. Where baseline
Table 1  Distribution of live births (lbirth) and neonatal deaths (nnd) by socio-economic position and year, in intervention and control areas

| Socio-economic position | Intervention | Control | Intervention and Control |
|-------------------------|--------------|---------|--------------------------|
|                         | baseline     | Year 1  | Year 2  | Year 3  | baseline | Year 1  | Year 2  | Year 3  | baseline | Year 1  | Year 2  | Year 3  | baseline | Year 1  | Year 2  | Year 3  | baseline | Year 1  | Year 2  | Year 3  | baseline | Year 1  | Year 2  | Year 3  |
|                         | lbirth (%)   | nnd     | lbirth (%) | nnd | lbirth (%) | nnd | lbirth (%) | nnd | lbirth (%) | nnd |
| Total                   | 2347        | 100%    | 145     | 3050 | 100%       | 167 | 3264       | 100% | 121       | 3074 | 100%       | 109 | 2162       | 100% | 116       | 2917 | 100%       | 153 | 2973       | 100% | 177       | 2929 | 100%       | 188 | 22716      | 100% | 1176      |
| Marginalisation         |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Most marginalised       | 823         | 35%     | 58      | 1058 | 35%        | 66 | 1021       | 31% | 31        | 889 | 29%        | 20 | 594        | 28% | 39        | 916 | 31%        | 62 | 843        | 28% | 46        | 795 | 27%        | 57 | 6939        | 31% | 379       |
| Less marginalised       | 1524        | 65%     | 87      | 1992 | 65%        | 101 | 2243       | 69% | 90        | 2185 | 71%       | 89 | 1568       | 72% | 77        | 2001 | 69%       | 91 | 2130       | 72% | 131       | 2134 | 73%       | 131 | 15777       | 69% | 797       |
| Literacy                |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Cannot read             | 1813        | 78%     | 125     | 2321 | 76%        | 129 | 2506       | 77% | 93        | 2292 | 75%       | 82 | 1489       | 70% | 85        | 2084 | 71%       | 118 | 2009       | 68% | 125       | 2016 | 69%       | 134 | 16530       | 73% | 891       |
| Can read (easily or with difficulty) | 526 | 22% | 19 | 729 | 24% | 38 | 758 | 25% | 28 | 782 | 25% | 27 | 653 | 30% | 29 | 833 | 29% | 35 | 964 | 32% | 52 | 913 | 31% | 54 | 6158 | 27% | 282       |
| Asset ownership         |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Poorest                 | 1692        | 72%     | 113     | 2183 | 72%        | 118 | 2331       | 71% | 97        | 2136 | 69%       | 72 | 1299       | 60% | 73        | 1742 | 60%       | 101 | 1721       | 58% | 106       | 1651 | 56%       | 122 | 14755       | 69% | 802       |
| Less poor               | 654         | 28%     | 32      | 867  | 28%        | 49 | 933        | 29% | 24        | 938  | 31%       | 37 | 863        | 40% | 43        | 1175 | 40%       | 52 | 1232       | 42% | 71        | 1278 | 44%       | 66 | 7960        | 35% | 374       |
| Land ownership          |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Landless or < 2 bighas  | 1431        | 62%     | 88      | 1856 | 61%        | 110 | 1825       | 56% | 57        | 1613 | 53%       | 52 | 1282       | 60% | 81        | 1812 | 62%       | 105 | 1825       | 62% | 106       | 1792 | 61%       | 120 | 13436       | 60% | 719       |
| Owns 2 or more bighas   | 891         | 38%     | 53      | 1172 | 39%        | 56 | 1426       | 44% | 63        | 1456 | 47%       | 57 | 857        | 40% | 35        | 1088 | 38%       | 46 | 1121       | 38% | 68        | 1129 | 39%       | 68 | 9140        | 40% | 446       |
| Caste/tribe             |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Scheduled Tribe or      | 1849        | 79%     | 118     | 2447 | 80%        | 141 | 2622       | 80% | 101       | 2450 | 80%       | 84 | 1570       | 73% | 90        | 2230 | 76%       | 123 | 2173       | 73% | 140       | 2102 | 72%       | 133 | 17443       | 77% | 930       |
| Scheduled Caste         |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |
| Other Backward Class    | 498         | 21%     | 27      | 603  | 20%        | 26 | 642        | 20% | 20        | 624  | 20%       | 25 | 592        | 27% | 26        | 687  | 24%       | 30 | 800        | 27% | 37        | 827  | 28%       | 55 | 5373       | 23% | 246       |
| or other                |             |         |         |      |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |            |     |

The number of missing values differs across the socio-economic variables. There were 108 pairs of twins and 1 pair of triplets in the intervention areas and 116 pairs of twins in the control areas.

*Most marginalised: illiterate and poorest and landless or < 2 bigha’s and Scheduled Caste or Scheduled Tribe. Less marginalised: can read easily or with difficulty and/or less poor and/or owns ≥ 2 bigha’s land and/or Other Backward Class/other.*
Table 2  Trends in neonatal mortality according to socio-economic position for intervention and control areas, adjusted for clustering

|                           | Intervention NMR (per 1000 live births) | Control NMR (per 1000 live births) | P-value for difference in trend between intervention and controlc |
|---------------------------|----------------------------------------|------------------------------------|-----------------------------------------------------------------|
|                           | baseline  Y1  Y2  Y3  change (%)a  P-valueb | baseline  Y1  Y2  Y3  change (%)a  P-valueb |                                                                 |
| **Total**                 | 60  53  36  35  -48  0.000 | 52  51  58  63  26  0.046 | 0.000                                                          |
| **Marginalisation**       |                                        |                                    |                                                                 |
| Most marginalised         | 68  60  29  22  -71  0.000 | 63  65  53  70  4  0.844 | 0.000                                                          |
| Less marginalised         | 56  50  40  40  -33  0.007 | 48  45  60  60  37  0.022 | 0.000                                                          |
| **Literacy**              |                                        |                                    |                                                                 |
| Cannot read               | 67  54  36  35  -54  0.000 | 55  55  60  64  21  0.161 | 0.000                                                          |
| Can read (easily or with difficulty) | 36  51  37  34  -18  0.454 | 44  42  54  59  46  0.091 | 0.098                                                          |
| **Asset ownership**       |                                        |                                    |                                                                 |
| Poorest                   | 65  52  40  33  -52  0.000 | 55  56  60  72  35  0.038 | 0.000                                                          |
| Less poor                 | 49  57  26  40  -37  0.054 | 49  44  56  51  14  0.499 | 0.054                                                          |
| **Land ownership**        |                                        |                                    |                                                                 |
| Landless or < 2 bighas    | 60  58  31  32  -56  0.000 | 62  56  57  66  9  0.559 | 0.000                                                          |
| Owns 2 or more bighas     | 59  47  43  38  -35  0.021 | 40  42  60  59  62  0.014 | 0.001                                                          |
| **Caste/tribe**           |                                        |                                    |                                                                 |
| Scheduled Tribe or Scheduled Caste | 62  55  37  33  -51  0.000 | 56  54  63  62  17  0.223 | 0.000                                                          |
| Other Backward Class or other | 55  44  32  40  -33  0.156 | 43  43  45  65  59  0.05  | 0.019                                                          |

aEstimated % change in NMR between baseline and year 3 assuming a linear trend
bP-value for change in NMR
cP-value for difference in trend between intervention and control for each population group
differences could explain the observed intervention effects, we have reported this in the text.

The quadrature approximation of the random-effects estimators was checked for all models. The Stata 10 software system (Stata, College Station, TX, USA) was used for all analyses. Ethics approval for the trial was received from an independent ethics committee (chaired by Dr A.K. Debdas) on the 14 June 2005 and from the Research Ethics Committee at the UCL Institute of Child Health.

### Results

#### Description

In the intervention arm of the study, the NMR declined by more than 50% between baseline and year 3 among lower socio-economic groups, and by 71% among the most socio-economically marginalised groups (Table 2). Among higher socio-economic groups in the intervention arm, the NMR also declined, but less strongly. The difference in mortality trend between the most and less marginalised in the intervention areas was such that the mortality disadvantage of the most marginalised disappeared, and even reversed in year 3 (OR for the most/less marginalised in year 3: 0.54 (95% CI: 0.33, 0.90), results not shown). In the control areas, the NMR remained stable or increased among all social groups.

In a replication of the trial analysis, a large intervention effect was observed among lower socio-economic groups, and even among the most marginalised groups in the study (Table 3). Moreover, the effect was stronger among the most compared with the less marginalised groups, with an estimated 59% effect in years 2 and 3 (70% in year 3) among the most marginalised as compared with an estimated 36% effect (35% in year 3) among the less marginalised (P-value for difference: 0.028 for years 2–3; 0.009 for year 3). The stronger effects among the most compared with the less marginalised are slightly inflated by baseline differences, but only to a small extent (Figure 1). Also for the other dimensions of stratification, effects were consistently stronger among lower strata, though the contrasts were less stark, and there was no power to detect these smaller differences.

#### Explanation

The stronger effect of the intervention among the most marginalised groups in the study was, in the

| Table 3 | Effects of intervention for total population and for lower and higher socio-economic groups, adjusted for clustering |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | NMR Intervention | NMR Control     | OR (95% CI)     | P-value         |
|                | Y 2 + 3          | Y 2 + 3         |                 |                 |
| Total          | 36               | 61              | 0.57 (0.46; 0.69)| 0.000           |
| Marginalisation|                 |                 |                 | 0.028           |
| Most marginalised | 26             | 62              | 0.41 (0.28; 0.59)|                 |
| Less marginalised | 40            | 61              | 0.64 (0.51; 0.80)|                 |
| Literacy       |                 |                 |                 | 0.584           |
| Cannot read    | 36              | 63              | 0.55 (0.44; 0.69)|                 |
| Can read (easily or with difficulty) | 35            | 56              | 0.61 (0.43; 0.87)|                 |
| Asset ownership|                 |                 |                 | 0.569           |
| Poorest        | 37              | 67              | 0.53 (0.43; 0.67)|                 |
| Less poor      | 33              | 54              | 0.60 (0.43; 0.83)|                 |
| Land ownership |                 |                 |                 | 0.079           |
| Landless or < 2 bighas | 31        | 62              | 0.49 (0.38; 0.63)|                 |
| Owns 2 or more bighas | 41        | 59              | 0.67 (0.51; 0.89)|                 |
| Caste/tribe    |                 |                 |                 | 0.638           |
| Scheduled Tribe or Scheduled Caste | 36        | 63              | 0.55 (0.44; 0.69)|                 |
| Other Backward Class or other | 35        | 56              | 0.61 (0.42; 0.89)|                 |

*aOdds ratio for neonatal mortality in the intervention as compared with the control areas of the study.  
*bP-value for the test on difference in OR between the low and high socio-economic position categories. For the total population, the table gives the P-value for the the difference between the intervention and control areas of the study.
first instance, concentrated in early NMR (Figure 2a). In year 3, this was complemented by an effect on the late NMR. The stronger effects on the total and early NMR were concentrated in winter (Figure 2b). Strong seasonal fluctuations, in particular winter peaks, largely in early NMR, were observed in the control areas of the study (results not shown). In the intervention areas, by contrast, these winter peaks largely disappeared over the course of the trial, especially among the most marginalised groups. The stronger effects of the intervention on late NMR in year 3 may have occurred in all seasons of the year, but confidence intervals were wide. Among the three major direct causes of neonatal death, prematurity and asphyxia may have contributed most to the stronger effect on early NMR in winter (Figure 2c) and infections to the stronger effect on late NMR in year 3.

The intervention may have influenced food intake during pregnancy, thermal care (except wrapping), and breastfeeding among the most and the less marginalised groups in the study areas, but confidence intervals were wide. Among the three major direct causes of neonatal death, prematurity and asphyxia may have contributed most to the stronger effect on early NMR in winter (Figure 2c) and infections to the stronger effect on late NMR in year 3.

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Evaluation of data and methods
Measurement bias is unlikely to explain our findings. Neonatal mortality rate was the primary outcome measure of the original trial, and stringent measures were taken to ensure completeness and reliability of the data relating to this measure. Birth and newborn death data in the trial were collected through prospective surveillance, which constitutes an important advance over often-used retrospective surveys, which rely on mothers’ recall.

At baseline, the differences in NMR in the intervention and control arms of the study were largely comparable among the most and less marginalised groups. Although the stronger effect of intervention among the most as compared with the less marginalised groups is probably slightly inflated by baseline differences, this is so only to a small extent. Programmes supported by the government of India, such as the Integrated Child Development Service, were present in the study area. Some such programs

Discussion
Our study shows that the women’s group intervention strongly reduced the NMR among lower socio-economic groups in the areas of India in which the study was conducted. The effects were substantially stronger among the most socio-economically marginalised groups. This is remarkable, given that interventions often lead to increasing, rather than declining, socio-economic inequalities in mortality. Our findings are important in view of the paucity of evidence for specifically effective means for reducing socio-economic inequalities in mortality. We show that a low-cost participatory community intervention can contribute to an equitable achievement of MDG4.
a. Intervention effects (comparing intervention and control areas) on early and late neonatal mortality rate among the most and less marginalised groups in the study.

P-values are given for the difference in intervention effect between the most and less marginalised groups. (Number of early neonatal deaths: 799; number of late neonatal deaths: 377).

b. The intervention effect on total neonatal mortality rate and early and late neonatal mortality rate by season

| Season  | NMR Y1-3 OR (95% CI) | P-value for difference (\( p \)) | Early NMR Y1-3 OR (95% CI) | P-value for difference (\( p \)) | Late NMR Y3 OR (95% CI) | P-value for difference (\( p \)) |
|---------|----------------------|----------------------------------|-----------------------------|----------------------------------|--------------------------|----------------------------------|
| Monsoon |                      |                                  |                             |                                  |                          |                                  |
| Most marginalised | 0.89 (0.57; 1.39) | 0.694                            | 0.73 (0.43; 1.23)           | 0.319                            | 0.83 (0.19; 3.65)        | 0.479                            |
| Less marginalised  | 0.99 (0.72; 1.36) |                                  | 1.00 (0.71; 1.40)           |                                  | 1.50 (0.62; 3.63)        |                                  |
| Winter       |                      |                                  |                             |                                  |                          |                                  |
| Most marginalised | 0.40 (0.25; 0.63) | 0.013                            | 0.24 (0.13; 0.45)           | 0.005                            | 0.27 (0.05; 1.40)        | 0.151                            |
| Less marginalised  | 0.75 (0.55; 1.03) |                                  | 0.65 (0.45; 0.94)           |                                  | 1.00 (0.44; 2.32)        |                                  |
| Summer       |                      |                                  |                             |                                  |                          |                                  |
| Most marginalised | 0.63 (0.40; 0.98) | 0.732                            | 0.67 (0.38; 1.16)           | 0.487                            | 0.73 (0.28; 1.94)        | 0.083                            |
| Less marginalised  | 0.57 (0.42; 0.78) |                                  | 0.53 (0.37; 0.75)           |                                  |                          |                                  |

*p*-value for difference between the most and less marginalised. Monsoon: July–October, winter: November-February, summer: March-June.

c. The intervention effects (comparing intervention and control areas) on cause specific mortality, among the most and less marginalised groups.

P-values are given for the difference in intervention effect between most and less marginalised. NA: Too few cases were available to conduct analyses for asphyxia (0 deaths) and prematurity (7 deaths) in the late neonatal period.

Figure 2 Effects of intervention on the early and late neonatal mortality rate among the most and less marginalised groups in the study by year, season, and cause of death
### Table 4
Health behaviours: cluster-adjusted percentages and odds ratios in a comparison of intervention and control areas of the study, for years 2 and 3 combined

|                  | Intervention marginalised | Intervention less marginalised | Control marginalised | Control less marginalised | OR (95%CI) marginalised | OR (95%CI) less marginalised | \( P \)-value difference |
|------------------|---------------------------|-------------------------------|----------------------|--------------------------|-------------------------|-----------------------------|--------------------------|
|                  | number | %     | number | %     | number | %     | number | %     |                  |                         |                         |                          |
| **Denominators** |         |       |         |       |         |       |         |       |                  |                         |                         |                          |
| Mothers with live births | 1897    | 4384  | 1612   | 4219  |          |       |          |       |                  |                         |                         |                          |
| Mothers with live births - home deliveries only | 1706    | 3616  | 1448   | 3113  |          |       |          |       |                  |                         |                         |                          |
| Live born infants | 1910    | 4428  | 1638   | 4264  |          |       |          |       |                  |                         |                         |                          |
| Live born infants - home deliveries only | 3455    | 6701  | 2817   | 6073  |          |       |          |       |                  |                         |                         |                          |
| **Determinants of prematurity** |         |       |         |       |         |       |         |       |                  |                         |                         |                          |
| Did not eat less during pregnancy (*) | 1087    | 62    | 1011   | 67    | 1.68   | (0.72; 3.91) | 1.55   | (0.67; 3.58) | 0.428                  |                         |                         |                          |
| Birth interval (*) | 1125    | 75    | 1091   | 76    | 1.08   | (0.86; 1.34) | 1.03   | (0.86; 1.23) | 0.703                  |                         |                         |                          |
| **Thermal care and breastfeeding** |         |       |         |       |         |       |         |       |                  |                         |                         |                          |
| Infant wiped within 30 mins () | 941     | 69    | 864    | 62    | 1.42   | (0.39; 5.21) | 1.13   | (0.31; 4.11) | 0.077                  |                         |                         |                          |
| Infant wrapped within 30 mins () | 569     | 28    | 501    | 35    | 0.78   | (0.23; 2.67) | 0.72   | (0.21; 2.46) | 0.508                  |                         |                         |                          |
| Infant not bathed within 24hrs () | 474     | 27    | 437    | 34    | 1.40   | (0.59; 3.34) | 1.29   | (0.55; 3.02) | 0.487                  |                         |                         |                          |
| Infant put to breast within 4hrs () | 1290    | 70    | 1150   | 74    | 1.19   | (0.45; 3.16) | 1.20   | (0.46; 3.16) | 0.799                  |                         |                         |                          |
| **Hygiene** |         |       |         |       |         |       |         |       |                  |                         |                         |                          |
| Birth attendant washed hands with soap (†) | 619     | 37    | 538    | 48    | 4.30   | (1.95; 9.44) | 3.60   | (1.67; 7.78) | 0.166                  |                         |                         |                          |
| Plastic sheet used (†) | 347     | 19    | 300    | 20    | 3.59   | (2.05; 6.31) | 3.80   | (2.24; 6.47) | 0.712                  |                         |                         |                          |
| Cord cut with new or boiled blade () | 1444    | 88    | 1312   | 82    | 1.77   | (0.98; 3.19) | 1.79   | (1.10; 3.19) | 0.916                  |                         |                         |                          |
| Cord tied with boiled thread () | 573     | 29    | 514    | 34    | 6.12   | (2.65; 14.10) | 5.27   | (2.34; 11.88) | 0.293                  |                         |                         |                          |
| Cord undressed or dressed with antiseptic () | 1594    | 97    | 1489   | 96    | 1.11   | (0.36; 3.50) | 0.93   | (0.30; 2.87) | 0.318                  |                         |                         |                          |
| Hygiene combined index () | 154     | 5     | 147    | 6     | 26.87  | (7.85; 92.02) | 8.23   | (3.37; 20.09) | 0.018                  |                         |                         |                          |
| **Health care** |         |       |         |       |         |       |         |       |                  |                         |                         |                          |
| 3+ Antenatal care (*) | 447     | 21    | 404    | 35    | 0.67   | (0.30; 1.48) | 0.58   | (0.27; 1.27) | 0.179                  |                         |                         |                          |
| Institutional delivery (*) | 191     | 7     | 174    | 17    | 0.80   | (0.41; 1.55) | 0.64   | (0.35; 1.20) | 0.114                  |                         |                         |                          |
| Post-natal checkup for baby at medical facility (‡‡) | 70      | 2     | 61     | 5     | 0.65   | (0.27; 1.55) | 0.76   | (0.34; 1.72) | 0.415                  |                         |                         |                          |
| Visit to medical facility for sick child (‡‡) | 56      | 12    | 50     | 19    | 1.25   | (0.59; 2.63) | 0.85   | (0.45; 1.61) | 0.136                  |                         |                         |                          |

\( P \)-value difference gives the \( P \)-value for the difference in odds ratios between the most and less marginalised.

Hygiene combined index: 1 if scored yes on all hygiene practices; the remainder are categorised as 0.

Denominators used for each of the variables: (*) mothers with live births; (†) mothers with live births - home deliveries only; (‡‡) live born infants; (‡‡) live born infants - home deliveries only; (‡‡‡) infants who had suffered an infant illness in the first 28 days of life – infants that were alive at 28 days only.
even target the poor, such as the subsidised food grains for people with Below Poverty Line cards. These programmes were, however, similarly common in both arms of the trial. More generally, because the study used a randomised design, potential confounders are expected to be evenly distributed between the study arms.

Mechanisms

Two complementary mechanisms may explain the stronger intervention effect among the most marginalised groups in the study. First, the uptake of the intervention (women’s group attendance, behavioural improvements) was similar among the most and less marginalised groups, whereas interventions normally reach higher socio-economic groups to a greater extent. The openness of the women’s groups in the study to non-members, the accessible language used, the picture cards employed to utilize visual literacy, the use of games and stories that relate to the experiences of the most marginalised groups, the locations (hamlets instead of the main village), the dates and timings (decided by the group members) of the meetings, and the Scheduled Tribe background of many of the facilitators probably made the intervention effectively reach groups that are normally left out of health interventions.

Second, when their utilization is similar, then effective and appropriate interventions arguably have stronger effects on mortality among high-risk groups. The fairly simple home-care practices discussed in the women’s group meetings in the Ekjut trial probably addressed important causes of death among groups with high rates of neonatal mortality. Neonatal death often results from a combination of and interaction between morbidities. Therefore, the spin-off effects of addressing one risk factor on other risk factors are arguably greater among the more vulnerable. This has been reported for immunisation, refuting the replacement mortality hypothesis. Similarly, addressing infection brings greater survival benefits to babies of low birth weight. Likewise, the observed improvements in hygienic practices in the trial may have had stronger effects on mortality among the most marginalised groups.

If similar behavioural improvements have stronger mortality effects among vulnerable groups, this is arguably even more true for babies born in these groups in the risky winter season, especially those who are born too small or prematurely or both. A major success of the intervention described here was its strong effect on the NMR in winter among the most marginalised groups. Winter in India is associated with a much higher prevalence of newborn hypothermia than is the case in summer. Hypothermia, prematurity, asphyxia and infection, are interacting causes of neonatal death. Premature or small babies are at a higher risk of hypothermia, infections, and asphyxia than are babies of normal weight. The observed improvements in hygienic practices, and perhaps thermal care, may have had particularly strong effects on mortality among the most marginalised groups during winter.

Similarly, newborn deaths often result from a combination of omissions and commissions, rather than from one isolated behaviour. In other words, multiple component causes together constitute a sufficient cause of death. Many different combinations of behaviours can constitute a sufficient cause of death. Small behavioural improvements, in the right combinations, in a small group of vulnerable babies, may not be easily discernible in population data. Even in rural India, where neonatal mortality is an important problem, most newborns do survive. Perhaps, through the women’s groups in the Ekjut trial, the most marginalised populations have become more pro-active and more alert, reacting more quickly to problems such as cold weather or a small baby (Box 1). Thus, small changes in a range of behaviors, or component causes, in a vulnerable group may lead to large decreases in newborn mortality, even without population-wide behavioural improvements.

Although a reduction in mortality from asphyxia, especially in winter, is not implausible, given the focus of the intervention on the perinatal period, with discourse about the cleaning of newborn infants’ airways, the uncertainty surrounding a single cause-of-death is large. Clinical presentations of prematurity, hypothermia, infection, and asphyxia can overlap and be difficult to distinguish with verbal autopsy data. Neonates with sepsis, for example, may present with respiratory distress, and asphyxiated infants can present with hypothermia.

Caution is also needed when interpreting behavioural data. The behaviours in the present trial were measured at 6 weeks post-partum and depended on maternal recall; in particular, differential misclassification may occur between the mothers of surviving newborns and of newborns that die. Unmeasured behaviours, such as the quality of wrapping of an infant, which is important to prevent hypothermia, may also have played a role in the effect of the trial.

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**Box 1**

Minka, a young mother, stated that “My child was delivered at home. She had a low birth weight, as she was born before her due month. The group members, who assisted me during my delivery, told me that the baby had a low birth weight and had to be kept warm, with her body covered. I was to exclusively breastfeed my baby and was advised not to bathe her till she had gained weight. I exclusively breastfed her and protected her from cold by keeping her covered. I maintained cleanliness. Now she is healthy.”
Additionally, unmeasured behavioural restrictions, e.g. relating to a ritual understanding of pollution among the members of Other Backward Classes and other castes in the trial, may have tempered the decline in mortality among the less marginalised groups.

**Implications**

This study shows that socio-economic inequalities in neonatal mortality can be reduced through community-based participatory intervention. We argue that effective interventions, given equal coverage, can have stronger effects on newborns at high risk for mortality, especially if they are triply vulnerable: socio-economically (the most marginalised), seasonally (born in winter), and physically (born premature/small and/or at risk of developing asphyxia because of a lack of skilled birth attendance). The challenge in reducing inequalities in newborn mortality therefore lies in ensuring an equitable uptake of effective interventions. Villages are not monolithic. The challenge is to make institutions and initiatives, like self-help groups and community health-worker schemes, inclusive. Ekjut’s strategy seems to work well, with the use of regional targeting (selecting underserved areas in poor districts in poor states), combined with a universal strategy at the community level (ensuring that no person is omitted and that social cohesion is not disrupted by overt-targeting or by inclusion or exclusion criteria), while ensuring that the messages and activities of the intervention are understandable for and refer to those who need them most. Arguably, equity is a design issue, with universal coverage combined with ‘soft’ targeting (targeting by fitting the intervention design to the target group rather than by applying strict inclusion and exclusion criteria) contributing to equitable outcomes. Obviously, the intervention needs to be effective in the first place, and of sufficient duration and intensity to ensure an effect on mortality, explaining the divergence between an equitable intervention uptake and the lack of an equitable effect on mortality in some studies.

Our study shows that reducing the NMR and inequalities in NMRs is feasible in high-mortality contexts, even without improvements in routine health care. The trial achieved substantial reductions in mortality, and even in rates of early neonatal mortality, with rates of institutional delivery that remained extremely low, especially among the most marginalised groups in the study. We cannot exclude the possibility that the utilization of health care in emergency situations, such as newborn illness, contributed to this. However, use of such care remained much lower among the most as compared with the less marginalised groups, and therefore is not the full explanation for the results of the study. Clearly, improving access to and quality of health care is vital. However, our findings show that there is no need to wait for this in high-mortality contexts.

Little is known about how to reach lower socio-economic groups and reduce socio-economic inequalities in health. The Commission on Social Determinants of Health recommends that the equity impacts of interventions be monitored to help fill the deficiency in evidence on how this might be accomplished. Our study suggests that universal coverage of effective interventions combined with their ‘soft targeting’ of high-risk groups can have very substantial and equitable effects on mortality.

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**KEY MESSAGES**

- The effects of the women’s group intervention on NMR were substantially stronger among the most socio-economically marginalised than among less marginalised groups in the Ekjut trial.
- Socio-economic inequalities in neonatal mortality can be substantially reduced through a low-cost participatory community intervention.
- Universal coverage combined with ‘soft targeting’ of high-risk groups with effective interventions can have very substantial and equitable effects on mortality.
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