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

Tanja AJ Houweling,[1,2]* Prasanta Tripathy,[3] Nirmala Nair,[3] Shibanand Rath,[3] Suchitra Rath,[3] Rajkumar Gope,[3] Rajesh Sinha,[3] Caspar W Looman,[2] Anthony Costello[1] and Audrey Prost[1]

[1]Institute for Global Health, University College London, London, UK [2]Department of Public Health, Erasmus MC University Medical Center Rotterdam, Rotterdam, The Netherlands and [3]Ekjut, Chakradharpur, Jharkhand, India

*Corresponding author. Institute for Global Health, University College London, London, UK. E-mail: a.j.houweling@erasmusmc.nl

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.[20]

Reducing neonatal mortality is becoming increasingly important to achieve MDG4 ('reduce child mortality') as its relative contribution to under-5 mortality rises.[21] Although policy attention to newborn mortality has until recently been scant,[22] new initiatives for this have begun to emerge.[23] 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.[24–30] Little is known about the equity impact of community-based health interventions.[31] Although there are some accounts of reductions in inequality in health-related behavior,[32,33] there are also indications that they may reinforce existing social hierarchies,[34–36] 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[37] and inequalities in mortality in the country are large.[38-40] 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 45% decline in years 2 and 3 of the intervention).[28] 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.[28]

### 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.[28,41] We included all live births (singletons 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%).[28]

### 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.[42] 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:

$$
\begin{aligned}
\log \text{odds NND} = {} & \alpha + \beta_1(\text{YearL\_i}) + \beta_2(\text{YearL\_c}) \\
& + \beta_3(\text{YearH\_i}) + \beta_4(\text{YearH\_c}) + \beta_5(\text{Contint}) + \beta_6(\text{SEP}) \\
& + \beta_7(\text{Contint*SEP}) + \beta_8(\text{STRATA}) + u_i + \varepsilon_j
\end{aligned}
\tag{1}
$$

where YearL_i, YearL_c, YearH_i, and YearH_c 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:

$$
\begin{aligned}
\log \text{odds NND} = {} & \alpha + \beta_1(\text{INT\_L}) + \beta_2(\text{INT\_H}) \\
& + \beta_3(\text{SEP}) + \beta_4(\text{STRATA}) + u_i + \varepsilon_j
\end{aligned}
\tag{2}
$$

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).

$$
\begin{aligned}
\log \text{odds NND} = {} & \alpha + \beta_1(\text{INT\_H}) + \beta_2(\text{SEP}) \\
& + \beta_3(\text{SEP} * \text{INT\_H}) + \beta_4(\text{STRATA}) + u_i + \varepsilon_j
\end{aligned}
\tag{3}
$$

where SEP*INT_H is the difference in 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 | | | Total | | |
| | lbirth | (%) | nnd | lbirth | (%) | nnd | lbirth | (%) | nnd | lbirth | (%) | nnd | 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**[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | 23% | 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 | 65% | 802 |
| Less poor | 654 | 28% | 32 | 867 | 28% | 49 | 933 | 29% | 24 | 938 | 31% | 37 | 863 | 40% | 43 | 1175 | 40% | 52 | 1252 | 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 Scheduled Caste | 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 |
| Other Backward Class or other | 498 | 21% | 27 | 603 | 20% | 26 | 642 | 20% | 20 | 624 | 20% | 25 | 592 | 27% | 26 | 687 | 24% | 30 | 800 | 27% | 37 | 827 | 28% | 55 | 5273 | 23% | 246 |

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.

[a] 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 | | | | | | Control | | | | | | P-value for difference in trend between intervention and control[c] |
| | NMR (per 1000 live births) | | | | | | NMR (per 1000 live births) | | | | | | |
| | baseline | Y1 | Y2 | Y3 | change (%)[a] | P-value[b] | baseline | Y1 | Y2 | Y3 | change (%)[a] | P-value[b] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 |

[a]Estimated % change in NMR between baseline and year 3 assuming a linear trend
[b]P-value for change in NMR
[c]P-value for difference in trend between intervention and control for each population group

**Table 3** Effects of intervention for total population and for lower and higher socio-economic groups, adjusted for clustering

| | NMR Intervention Y 2 + 3 | NMR Control Y 2 + 3 | OR (95% CI)[a] | P-value[b] |
|---|---|---|---|---|
| **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) | |

[a]Odds ratio for neonatal mortality in the intervention as compared with the control areas of the study.
[b]P-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.

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 as 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
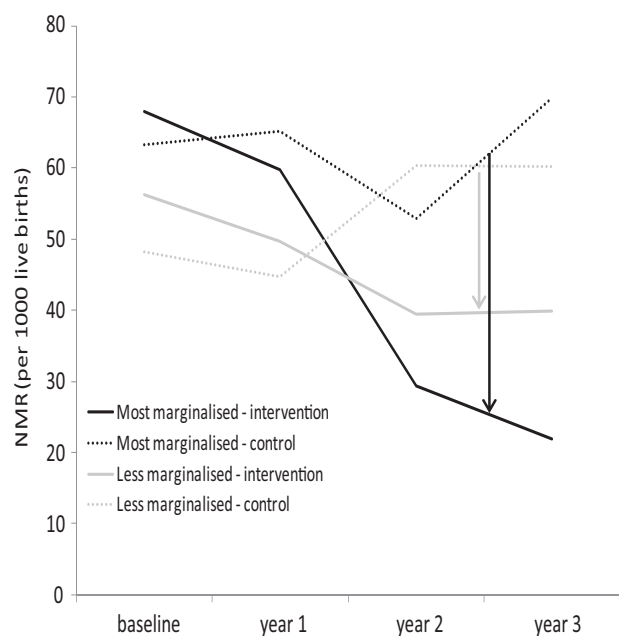
**Figure 1** Neonatal mortality rate (adjusted for clustering) among the most marginalised and less marginalised groups in intervention and control areas per year. The arrows indicate the intervention effect among the most and the less marginalised groups in years 2 and 3 combined, taking into account that differences at baseline are small

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 very wide and included 1 (Table 4). There was an effect on some hygienic practices for home deliveries, especially hand washing with soap by the birth attendant, and use of a plastic sheet, a new or boiled blade to cut the umbilical cord, and a boiled thread to tie the cord. These effects were comparable among the most and the less marginalised groups. Only the proportion of home deliveries for

which all hygienic practices were used was higher ($P = 0.018$) among the most marginalised groups, although in absolute terms the differences in effect were small and could have been due to multiple testing.

There was no effect of the intervention on the utilization of health care among the most and less marginalised groups in the study. We cannot exclude the possibility of increased use of health care in cases of emergency situations, such as neonatal illness or prolonged labour, but the confidence intervals were wide.

Attendance at the women's groups strongly increased over time, but differences in attendance between the most and less marginalised groups remained small in absolute terms. Attendance increased from 11% and 15% of deliveries among the most and the less marginalised, respectively, in year 1, to 59% and 52% among the most and the less marginalised, respectively, in year 3 (results not shown).

## 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.[7,12,14,43,44] 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[45] participatory community intervention can contribute to an equitable achievement of MDG4.

### 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.[41] Birth and newborn death data in the trial were collected through prospective surveillance,[41] which constitutes an important advance over often-used retrospective surveys, which rely on mothers' recall.[46–47]

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

*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.
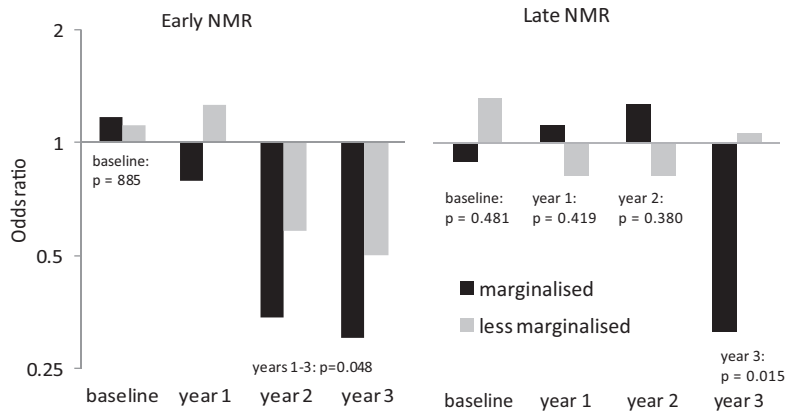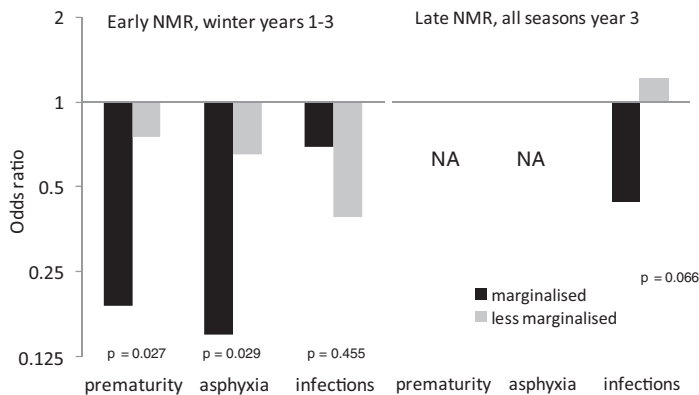


*P*-values are given for the difference in intervention effect between the most and less marginalised groups. (Number of early neonatal deaths: 799; number of late neonatal deaths: 377).

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

|  | NMR Y1-3 OR (95% CI) | P-value for difference (*) | Early NMR Y1-3 OR (95% CI) | P-value for difference (*) | Late NMR Y3 OR (95%CI) | P-value for difference (*) |
|---|---|---|---|---|---|---|
| *Monsoon* |  |  |  |  |  |  |
| Most marginalised | 0.89 (0.57; 1.39) |  | 0.73 (0.43; 1.23) |  | 0.83 (0.19; 3.65) |  |
| Less marginalised | 0.99 (0.72; 1.36) | 0.674 | 1.00 (0.71; 1.40) | 0.319 | 1.50 (0.62; 3.63) | 0.479 |
| *Winter* |  |  |  |  |  |  |
| Most marginalised | 0.40 (0.25; 0.63) |  | 0.24 (0.13; 0.45) |  | 0.27 (0.05; 1.40) |  |
| Less marginalised | 0.75 (0.55; 1.03) | 0.013 | 0.65 (0.45; 0.94) | 0.005 | 1.00 (0.44; 2.32) | 0.151 |
| *Summer* |  |  |  |  |  |  |
| Most marginalised | 0.63 (0.40; 0.98) |  | 0.67 (0.38; 1.16) |  | 0.10 (0.01; 0.77) |  |
| Less marginalised | 0.57 (0.42; 0.78) | 0.732 | 0.53 (0.37; 0.75) | 0.487 | 0.73 (0.28; 1.94) | 0.083 |

*\*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

| | Years 2-3 | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | 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 | 2844 | 59 | 739 | 49 | 2111 | 48 | 1.68 | (0.72; 3.91) | 1.55 | (0.67; 3.58) | 0.428 |
| Birth interval (*) | 1125 | 75 | 2281 | 77 | 945 | 74 | 2127 | 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 | 2563 | 70 | 928 | 61 | 2014 | 67 | 1.42 | (0.39; 5.21) | 1.13 | (0.31; 4.11) | 0.077 |
| Infant wrapped within 30 mins (\|) | 569 | 28 | 1566 | 34 | 686 | 35 | 1391 | 40 | 0.78 | (0.23; 2.67) | 0.72 | (0.21; 2.46) | 0.508 |
| Infant not bathed within 24 hrs (\|) | 474 | 27 | 1215 | 32 | 247 | 20 | 794 | 27 | 1.40 | (0.59; 3.34) | 1.29 | (0.55; 3.02) | 0.487 |
| Infant put to breast within 4 hrs (‡‡) | 1290 | 70 | 2903 | 74 | 928 | 66 | 2671 | 70 | 1.19 | (0.45; 3.16) | 1.20 | (0.46; 3.16) | 0.799 |
| **Hygiene** | | | | | | | | | | | | |
| Birth attendant washed hands with soap (†) | 619 | 37 | 1710 | 48 | 190 | 13 | 717 | 20 | 4.30 | (1.95; 9.44) | 3.60 | (1.67; 7.78) | 0.166 |
| Plastic sheet used (†) | 347 | 19 | 774 | 20 | 106 | 6 | 251 | 6 | 3.59 | (2.05; 6.31) | 3.80 | (2.24; 6.47) | 0.712 |
| Cord cut with new or boiled blade (\|) | 1444 | 88 | 3271 | 93 | 1120 | 82 | 2696 | 88 | 1.77 | (0.98; 3.19) | 1.79 | (1.01; 3.19) | 0.916 |
| Cord tied with boiled thread (\|) | 573 | 29 | 1540 | 39 | 132 | 7 | 373 | 11 | 6.12 | (2.65; 14.10) | 5.27 | (2.34; 11.88) | 0.293 |
| Cord undressed or dressed with antiseptic (\|) | 1594 | 97 | 3299 | 96 | 1339 | 97 | 2896 | 97 | 1.11 | (0.36; 3.50) | 0.93 | (0.30; 2.87) | 0.318 |
| Hygiene combined index (\|) | 154 | 5 | 380 | 6 | 5 | 0 | 35 | 1 | 26.87 | (7.85; 92.02) | 8.23 | (3.37; 20.09) | 0.018 |
| **Health care** | | | | | | | | | | | | |
| 3+ Antenatal care (*) | 447 | 21 | 1595 | 36 | 475 | 27 | 1964 | 50 | 0.67 | (0.30; 1.48) | 0.58 | (0.27; 1.27) | 0.179 |
| Institutional delivery (*) | 191 | 7 | 768 | 17 | 164 | 8 | 1106 | 24 | 0.80 | (0.41; 1.55) | 0.64 | (0.35; 1.20) | 0.114 |
| Post-natal checkup for baby at medical facility (‡‡) | 70 | 2 | 495 | 5 | 59 | 3 | 378 | 7 | 0.65 | (0.27; 1.55) | 0.76 | (0.34; 1.72) | 0.415 |
| Visit to medical facility for sick child (††) | 56 | 12 | 183 | 19 | 43 | 9 | 279 | 22 | 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; (‡‡) 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.[48]

Second, when their utilization is similar, then effective and appropriate interventions arguably have stronger effects on mortality among high-risk groups.[49] 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.[50] This has been reported for immunisation, refuting the replacement mortality hypothesis.[51–53] Similarly, addressing infection brings greater survival benefits to babies of low birth weight.[50] 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.[50] 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.[54] Hypothermia, prematurity, asphyxia and infection, are interacting causes of neonatal death. Premature or small babies are at a higher risk of hypothermia,[54–55] infections,[56–57] and asphyxia[58] 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.[59] 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.[60] Neonates with sepsis, for example, may present with respiratory distress,[60] and asphyxiated infants can present with hypothermia.[54]

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.

---

**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.[14,61] 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[48] (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[20] (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.[32]

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.[62] 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.

**Conflict of interest:** None declared.

---

**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.

# References

1 Bryce J, Terreri N, Victora CG, Mason E, Daelmans B, Bhutta ZA et al. Countdown to 2015: tracking intervention coverage for child survival. Lancet. 2006;**368**:1067–76.

2 UNICEF. Progress for Children: Achieving the MDGs With Equity. New York: UNICEF, 2010.

3 World Bank. World Development Indicators 2010. Washington, DC: World Bank, 2010.

4 United Nations. The Millennium Development Goals Report 2010. New York: United Nations, 2010.

5 Save the Children. A Fair Chance at Life: Why Equity Matters for Child Mortality: A Save the Children Report for the 2010 Summit on the Millennium Development Goals. London: Save the Children, 2010.

6 Gwatkin DR, Rutstein S, Johnson K, Suliman E, Wagstaff A, Amouzou A. Socio-economic Differences in Health, Nutrition, and Population Within Developing Countries: An Overview. Washington: World Bank, 2007.

7 Houweling TAJ. Socio-economic inequalities in childhood mortality in low and middle income countries. (PhD thesis). Rotterdam: Erasmus MC University Medical Center Rotterdam, 2007.

8 Houweling TA, Ronsmans C, Campbell OM, Kunst AE. Huge poor-rich inequalities in maternity care: an international comparative study of maternity and child care in developing countries. Bull WHO 2007;**85**:745–54.

9 Houweling TA, Kunst AE. Socio-economic inequalities in childhood mortality in low and middle income countries: a review of the international evidence. Br Med Bull 2010; **93**:7–26.

10 Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS, Group BCSS. How many child deaths can we prevent this year? Lancet 2003;**362**:65–71.

11 Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L. Evidence-based, cost-effective interventions: how many newborn babies can we save? Lancet 2005;**365**: 977–88.

12 Victora CG, Vaughan JP, Barros FC, Silva AC, Tomasi E. Explaining trends in inequities: evidence from Brazilian child health studies. Lancet 2000;**356**:1093–8.

13 Filmer D. Fever and its treatment among the more and less poor in sub-Saharan Africa. Health Policy Plan 2005; **20**:337–46.

14 Gwatkin DR. The need for equity-oriented health sector reforms. Int J Epidemiol 2001;**30**:720–23.

15 Gwatkin DR. How well do health programmes reach the poor? Lancet 2003;**361**:540–41.

16 Powell-Jackson T, Neupane BD, Tiwari S, Tumbahangphe K, Manandhar D, Costello AM. The impact of nepal's national incentive programme to promote safe delivery in the district of Makwanpur. Adv Health Econ Health Serv Res 2009;**21**:221–49.

17 World Bank. World Development Report 2004: Making Services Work for Poor People. Washington, DC: Oxford University Press, World Bank, 2003.

18 Gakidou E, Oza S, Vidal Fuertes C, Li AY, Lee DK, Sousa A et al. Improving child survival through environmental and nutritional interventions: the importance of targeting interventions toward the poor. JAMA 2007;**298**: 1876–87.

19 Hart JT. The inverse care law. Lancet 1971;**1**:405–12.

20 Gwatkin DR, Wagstaff A, Yazbeck AS (eds). Reaching the Poor With Health, Nutrition, and Population Services: What Works, What Doesn't, and Why. Washington, DC: World Bank, 2005.

21 Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet 2003;**361**: 2226–34.

22 Lawn J. Are the millennium development goals on target? BMJ 2010;**341**:c5045.

23 Lawn JE, Cousens SN, Darmstadt GL, Bhutta ZA, Martines J, Paul V et al. 1 year after The Lancet Neonatal Survival Series–was the call for action heard? Lancet 2006; **367**:1541–47.

24 Bang AT, Bang RA, Baitule SB, Reddy MH, Deshmukh MD. Effect of home-based neonatal care and management of sepsis on neonatal mortality: field trial in rural India. Lancet 1999;**354**:1955–61.

25 Kumar V, Mohanty S, Kumar A, Misra RP, Santosham M, Awasthi S et al. Effect of community-based behaviour change management on neonatal mortality in Shivgarh, Uttar Pradesh, India: a cluster-randomised controlled trial. Lancet 2008;**372**:1151–62.

26 Baqui AH, El-Arifeen S, Darmstadt GL, Ahmed S, Williams EK, Seraji HR et al. Effect of community-based newborn-care intervention package implemented through two service-delivery strategies in Sylhet district, Bangladesh: a cluster-randomised controlled trial. Lancet 2008;**371**:1936–44.

27 Manandhar DS, Osrin D, Shrestha BP, Mesko N, Morrison J, Tumbahangphe KM et al. Effect of a participatory intervention with women's groups on birth outcomes in Nepal: cluster-randomised controlled trial. Lancet 2004;**364**:970–79.

28 Tripathy P, Nair N, Barnett S, Mahapatra R, Borghi J, Rath S et al. Effect of a participatory intervention with women's groups on birth outcomes and maternal depression in Jharkhand and Orissa, India: a cluster-randomised controlled trial. Lancet 2010;**375**:1182–92.

29 Crowe S, Utley M, Costello A, Pagel C. How many births in sub-Saharan Africa and South Asia will not be attended by a skilled birth attendant between 2011 and 2015? BMC Pregnancy Childbirth 2012;**12.**

30 UNICEF. Monitoring the status of children and women 2012; Available from http://www.childinfo.org/delivery_care_countrydata.php (2 April 2012, date last accessed).

31 Haines A, Sanders D, Lehmann U, Rowe AK, Lawn JE, Jan S et al. Achieving child survival goals: potential contribution of community health workers. Lancet 2007;**369**: 2121–31.

32 Baqui AH, Rosecrans AM, Williams EK, Agrawal PK, Ahmed S, Darmstadt GL et al. NGO facilitation of a government community-based maternal and neonatal health programme in rural India: improvements in equity. Health Policy Plan 2008;**23**:234–43.

33 Bishai D, Suzuki E, McQuestion M, Chakraborty J, Koenig M. The role of public health programmes in reducing socioeconomic inequities in childhood immunization coverage. Health Policy Plan 2002;**17**:412–19.

34 UNICEF. What Works for Children in South Asia. Community Health Workers. Katmandu, Nepal: UNICEF Regional Office for South Asia, 2004.

35 Bell D, Go R, Miguel C, Parks W, Bryan J. Unequal treatment access and malaria risk in a community-based intervention program in the Philippines. Southeast Asian J Trop Med Public Health 2005;**36**:578–86.

36 Kumar V, Kumar A, Darmstadt GL. Behavior change for newborn survival in resource-poor community settings: bridging the gap between evidence and impact. Semin Perinatol 2010;**34**:446–61.

37 Lawn JE, Cousens S, Bhutta ZA, Darmstadt GL, Martines J, Paul V *et al*. Why are 4 million newborn babies dying each year? *Lancet* 2004;**364:**399–401.

38 Houweling TA, Azad K, Younes L, Kuddus A, Shaha S, Haq B *et al*. The effect of participatory women's groups on birth outcomes in Bangladesh: does coverage matter? Study protocol for a randomized controlled trial. *Trials* 2011;**12:**208.

39 Houweling TA, Jayasinghe S, Chandola T. The social determinants of childhood mortality in Sri Lanka: time-trends & comparisons across South Asia. *Indian J Med Res* 2007;**126:**239–48.

40 Das Gupta P, Thorat S. *Will India's Attainment of the MDG's Be an Inclusive Process*. New Delhi: Indian Institute of Dalit Studies, 2009.

41 Barnett S, Nair N, Tripathy P, Borghi J, Rath S, Costello A. A prospective key informant surveillance system to measure maternal mortality–findings from indigenous populations in Jharkhand and Orissa, India. *BMC Pregnancy Childbirth.* 2008;**8:**6.

42 Pagel C, Prost A, Nair N, Tripathy P, Costello A, Utley M. Use of the Variable Life Adjusted Display (VLAD) for rapid monitoring of mortality trends over time in low-resource settings. *Bull WHO* (in press).

43 Victora CG, Huicho L, Amaral JJ *et al*. Are health interventions implemented where they are most needed? District uptake of the integrated management of childhood illness strategy in Brazil, Peru and the United Republic of Tanzania. *Bull WHO* 2006;**84:**792–801.

44 World Bank. *Poverty and Social Exclusion in India*. Washington, DC: World Bank, 2011.

45 Borghi J, Thapa B, Osrin D, Jan S, Morrison J, Tamang S *et al*. Economic assessment of a women's group intervention to improve birth outcomes in rural Nepal. *Lancet* 2005;**366:**1882–84.

46 Oestergaard MZ, Inoue M, Yoshida S *et al*. Neonatal Mortality Levels for 193 Countries in 2009 with Trends since 1990: A Systematic Analysis of Progress, Projections, and Priorities. *PLoS Med* 2011;**8:**e1001080.

47 Curtis SL. *Assessment of the Quality of Data Used for Direct Estimation of Infant and Child Mortality in DHS-II Surveys. Occasional Papers 3*. Calverton, MD: Macro International, 1995.

48 Rath S, Nair N, Tripathy PK, Barnett S, Mahapatra R, Gope R *et al*. Explaining the impact of a women's group led community mobilisation intervention on maternal and newborn health outcomes: the Ekjut trial process evaluation. *BMC Int Health Hum Rights* 2010;**10:**25.

49 Victora CG, Schellenberg JA, Huicho L, Amaral J, El Arifeen S, Pariyo G *et al*. Context matters: interpreting impact findings in child survival evaluations. *Health Policy Plan* 2005;**20 (Suppl 1):**i18–i31.

50 Bang AT, Reddy HM, Bang RA, Deshmukh MD. Why Do Neonates Die in Rural Gadchiroli, India? (Part II): Estimating population sttributable risks and contribution of multiple morbidities for identifying a strategy to prevent deaths. *J Perinatol* 2005;**25:**S35–S43.

51 Hill K. *Child Health Priorities for the 1990s*. Baltimore, MD: Johns Hopkins University Institute for International Programs, 1992.

52 Bishai D, Koenig M, Ali Khan M. Measles vaccination improves the equity of health outcomes: evidence from Bangladesh. *Health Econ* 2003;**12:**415–19.

53 Koenig MA, Bishai D, Khan MA. Health interventions and health equity: the example of measles vaccination in Bangladesh. *Population Dev Rev* 2001;**27:**283–302.

54 Kumar V, Shearer JC, Kumar A, Darmstadt GL. Neonatal hypothermia in low resource settings: a review. *J Perinatol* 2009;**29:**401–12.

55 Mullany LC, Katz J, Khatry SK, LeClerq SC, Darmstadt GL, Tielsch JM. Neonatal hypothermia and associated risk factors among newborns of southern Nepal. *BMC Med* 2010;**8:**43.

56 Sankar MJ, Agarwal R, Deorari AK, Paul VK. *Sepsis in the Newborn: AIIMS-NICU protocols*. India Institute of Medical Sciences, Neonatal Intensive Care Unit, 2008.

57 Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: when? *Where? Why? Lancet* 2005;**365:**891–900.

58 Lee AC, Mullany LC, Tielsch JM, Katz J, Khatry SK, LeClerq SC *et al*. Risk factors for neonatal mortality due to birth asphyxia in southern Nepal: a prospective, community-based cohort study. *Pediatrics* 2008;**121:** e1381–90.

59 Rothman KJ, Greenland S. *Modern Epidemiology*. 2nd edn. London: Lippincott Williams & Wilkins, 1998.

60 Lee AC, Mullany LC, Tielsch JM, Katz J, Khatry SK, LeClerq SC *et al*. Verbal autopsy methods to ascertain birth asphyxia deaths in a community-based setting in southern Nepal. *Pediatrics.* 2008;**121:**e1372–80.

61 Gwatkin DR. How much would poor people gain from faster progress towards the Millennium Development Goals for health? *Lancet* 2005;**365:**813–7.

62 Commission on Social Determinants of Health (CSDH). *Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health. Final Report*. 2008. Geneva: World Health Organization; http://www.who.int/social_determinants/final_report/en/.