

## Temporal and spatial pattern of infant mortality in Germany after unification

### Summary

**Objectives:** After unification in 1990 the two parts of Germany underwent a complex process that has led to convergence of infant mortality. The pattern of change did, however, differ in east and west. This study investigates whether these differences conceal a complex pattern of heterogeneity at the regional level.

**Methods:** Examination of routine data on infant, neonatal and postneonatal mortality. Time trends in the 16 federal states of Germany (*Länder*) from 1991 to 1997 were studied using a log-linear model.

**Results:** In 1991, infant mortality was higher in almost all eastern *Länder* than in the west. By 1997, this east-west gap had disappeared. Over this period, infant mortality fell in all *Länder* but one. The decline was steepest in the east, ranging from 31% to 52%. Improvements were largely due to steep declines in both neonatal and postneonatal mortality.

**Conclusions:** This study shows that, at the time of unification, there was an almost complete demarcation between east and west, a pattern that disappeared by 1997. There is, however, still a substantial regional variation in infant mortality that is largely determined by postneonatal mortality.

**Key-Words:** Infant mortality – Birth weight – Transition – Regional variation – Germany.

Since the fall of the Berlin Wall in 1989 the former communist countries of central and eastern Europe underwent substantial social and economic changes that also had a major impact on health<sup>1,2,3</sup>. While many countries experienced a health crisis that mainly affected male adults, infant mortality rates remained fairly stable across the region or actually fell in some countries<sup>4</sup>. Aggregate measures such as infant mortality, however, provide only limited information about the impact of transition on mortality in early life. They may conceal different trends in neonatal and postneonatal mortality as postneonatal mortality is strongly related to socio-economic factors<sup>5</sup> while neonatal mortality may more closely reflect the quality of medical care<sup>6</sup>.

In an earlier paper we showed how, since unification in 1990, infant mortality rates in the two parts of Germany converged<sup>7</sup>. This was due to improvements in neonatal and postneonatal mortality in both east and west, although the pattern of change differed between the two regions. These changes were associated with differences in the distribution of birth weight, which, in contrast to the improvements in mortality, actually showed a slight worsening in both east and west.

The analysis so far has been at the level of the two parts of Germany. However, it is important to recognise that Germany is a federal state, with 16 very diverse regions (*Länder*). Thus, the question arises as to whether these differences reflect a simple east-west demarcation or rather conceal a more complex pattern of regional heterogeneity. This paper examines how neonatal and postneonatal mortality have changed in the five federal states that were created from the territory of the former German Democratic Republic (GDR) – *Mecklenburg-West Pomerania, Brandenburg, Saxony-Anhalt, Saxony, Thuringia* (Fig. 1) – and in the 10 *Länder* of the old Federal Republic (FRG), plus the Land Berlin, formed by unifying East Berlin and West Berlin.



Figure 1 The federal states of Germany in the 1990s

## Methods

Data on infant, neonatal and postneonatal mortality for all 16 German federal states were obtained from the Federal Statistical Office Germany for the period 1990 to 1997. Formal evaluation of data quality from the Statistical Office has not been available but as registration of each birth and death is required by law, the numbers provided are to be seen as, virtually, complete.

Neonatal and postneonatal mortality were analysed separately, with neonatal mortality relating to deaths occurring within the first 28 days of life, and postneonatal mortality to subsequent deaths within the first year of life. Rates were calculated as the number of neonatal or postneonatal deaths in a given year per 1000 live births. In 1990, the western definition of a live birth was introduced in the former GDR, which requires presence of a heart beat *or* breathing *or* a pulsating umbilical cord, compared with the former eastern definition of presence of a heart beat *and* breathing<sup>8</sup>. This introduced some discontinuities in data from 1990, with, for example, the proportion of reported neonatal deaths in the extremely low birth weight group, at less than 1000 g, being unusually low in all eastern Länder, at 10–20% in 1990, compared with 30–35% in the west. Because of these problems, trends in infant, neonatal and postneonatal mortality

in each federal state were analysed for the period 1991 to 1997.

To describe trends, log-linear models were fitted to the calculated rates as trends in infant mortality tend to follow a constant proportional change rather than constant absolute change<sup>9,10</sup>. Regression estimates ( $\beta$ ), as a measure of the annual per cent change in infant and neo-/postneonatal mortality, respectively, and test statistics were obtained by using weighted least square algorithms. Statistical significance of assessed trends was tested by an analysis of variance procedure (ANOVA); 95% confidence intervals were estimated according to standard methods<sup>11</sup>.

Analyses were carried out using the SPSS statistical package and the Microsoft Excel spreadsheet<sup>12,13</sup>. Throughout this paper, the phrase ‘*new Länder*’ or ‘east’ refers to the territory of the former GDR before unification, including East Berlin, and ‘*old Länder*’ or ‘west’ to the territory of the old Federal Republic including West Berlin.

## Results

### Infant mortality

Infant mortality showed a considerable regional variation from 6.0 per 1000 live births in Bremen to 9.1 in Saxony-Anhalt in 1991 and from 4.2 in Baden-Württemberg to 6.2 in Bremen in 1997 (Tab. 1).

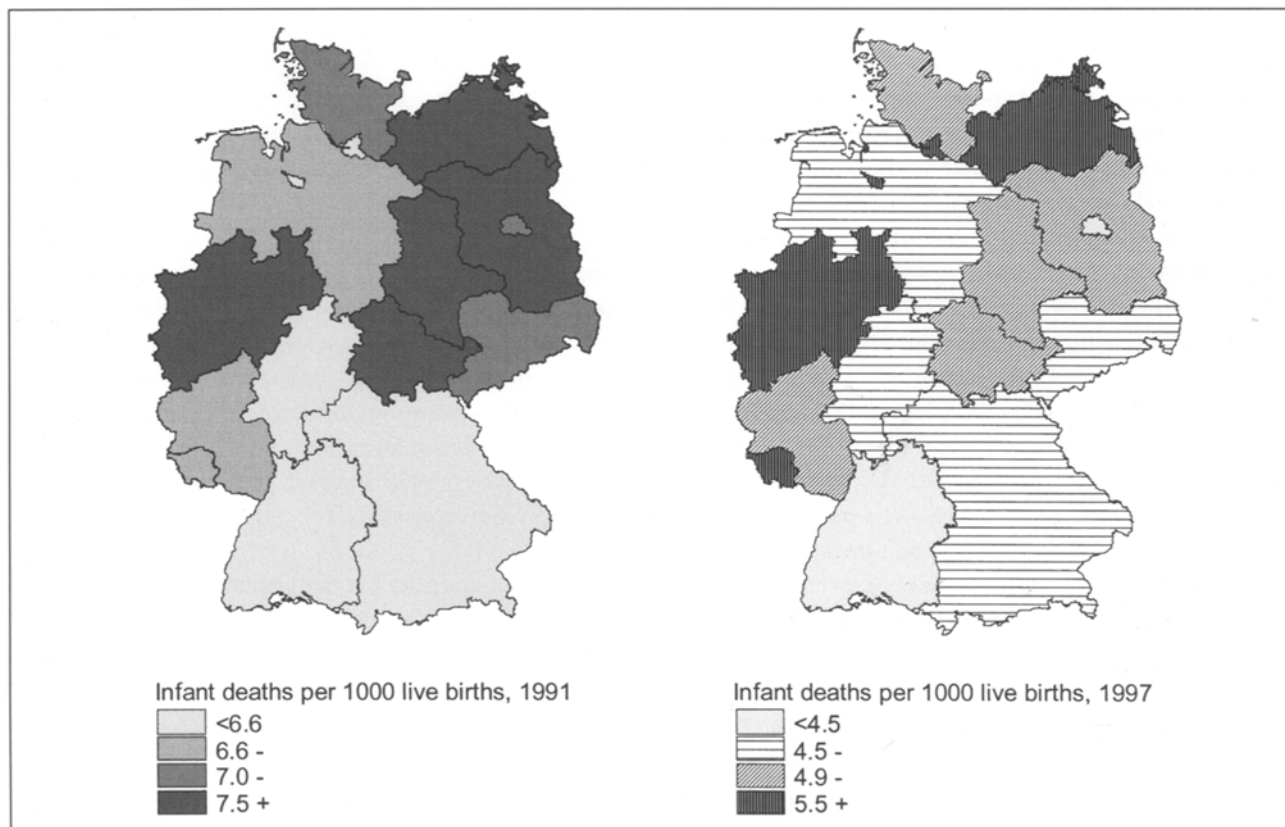
Figure 2 shows infant mortality rates, given in quartiles, by region in 1991 and 1997, with the rates for east and west Berlin combined. For 1991, it shows a clear east-west demarcation. By 1997, this east-west pattern has given way to a complex pattern with the highest rates in Bremen, Hamburg and North-Rhine Westphalia in the North of the old Federal Republic and Mecklenburg-West Pomerania in the North of the former GDR.

When ranking the Länder according to the slope of the change in each measure of mortality in the period 1991 to 1997, it emerges that the decline has been steeper in all east German Länder as compared to their western counterparts (Tab. 2). Within the regions “east” and “west”, however, there was a considerable variation in the size of the slope, with that observed for the eastern Land Saxony being much closer to those in some western Länder. Overall, the decline was statistically significant in all Länder except Hamburg, Saarland and Bremen, which actually experienced a small increase in infant mortality. However, the results have to be interpreted with caution as the number of deaths in these Länder were relatively small.

| Land                       | Infant deaths / 1000 live births |            |          | Neonatal deaths / 1000 live births |            |          | Postneonatal deaths / 1000 live births |            |          |
|----------------------------|----------------------------------|------------|----------|------------------------------------|------------|----------|--|------------|----------|
|                            | 1991                             | 1997       | % change | 1991                               | 1997       | % change | 1991                                   | 1997       | % change |
| Brandenburg                | 7.6 (130)*                       | 4.9 (80)   | -35      | 3.5 (61)                           | 3.0 (49)   | -16      | 4.0 (69)                               | 1.9 (31)   | -53      |
| Mecklenburg-West Pomerania | 8.1 (111)                        | 5.7 (68)   | -31      | 4.3 (59)                           | 3.5 (42)   | -19      | 3.8 (52)                               | 2.2 (26)   | -43      |
| Saxony                     | 7.1 (222)                        | 4.5 (129)  | -37      | 3.8 (120)                          | 3.2 (94)   | -15      | 3.3 (102)                              | 1.2 (35)   | -63      |
| Saxony-Anhalt              | 9.1 (177)                        | 5.0 (86)   | -45      | 4.1 (79)                           | 2.9 (50)   | -28      | 5.0 (98)                               | 2.7 (36)   | -58      |
| Thuringia                  | 8.0 (140)                        | 5.3 (87)   | -34      | 4.7 (82)                           | 3.5 (58)   | -25      | 3.3 (59)                               | 1.8 (29)   | -47      |
| East Berlin                | 7.9 (69)                         | 3.8 (35)   | -52      | 5.2 (45)                           | 1.8 (13)   | -73      | 2.8 (24)                               | 2.2 (22)   | -13      |
| West Berlin                | 7.1 (156)                        | 4.7 (99)   | -35      | 3.7 (81)                           | 2.1 (45)   | -43      | 3.4 (75)                               | 2.6 (54)   | -26      |
| Baden-Württemberg          | 6.0 (709)                        | 4.2 (485)  | -31      | 2.9 (343)                          | 2.5 (285)  | -16      | 3.1 (366)                              | 1.7 (200)  | -45      |
| Bavaria                    | 6.2 (834)                        | 4.5 (587)  | -28      | 3.2 (432)                          | 2.8 (365)  | -13      | 3.0 (402)                              | 1.7 (222)  | -43      |
| Bremen                     | 6.0 (41)                         | 6.2 (41)   | + 2      | 2.1 (14)                           | 3.6 (24)   | +75      | 4.0 (27)                               | 2.6 (17)   | -36      |
| Hamburg                    | 6.9 (114)                        | 5.8 (99)   | -16      | 3.6 (60)                           | 3.8 (64)   | + 4      | 3.3 (54)                               | 2.1 (35)   | -37      |
| Hesse                      | 6.2 (377)                        | 4.5 (283)  | -27      | 3.3 (202)                          | 2.9 (184)  | -12      | 2.9 (175)                              | 1.6 (99)   | -45      |
| Lower Saxony               | 6.7 (559)                        | 4.8 (409)  | -29      | 3.5 (292)                          | 2.6 (225)  | -25      | 3.2 (267)                              | 2.1 (184)  | -33      |
| North-Rhine Westphalia     | 7.5 (1497)                       | 5.5 (1042) | -27      | 3.9 (773)                          | 3.2 (614)  | -17      | 3.7 (724)                              | 2.3 (428)  | -38      |
| Rhineland-Palatine         | 6.8 (289)                        | 5.2 (217)  | -24      | 3.1 (132)                          | 2.8 (117)  | -10      | 3.7 (157)                              | 2.4 (100)  | -35      |
| Saarland                   | 6.9 (76)                         | 6.3 (63)   | - 8      | 3.3 (36)                           | 3.4 (34)   | + 5      | 3.6 (40)                               | 2.9 (29)   | -20      |
| Schleswig-Holstein         | 7.3 (210)                        | 4.9 (141)  | -33      | 3.1 (90)                           | 3.0 (88)   | - 3      | 4.2 (120)                              | 1.8 (53)   | -56      |
| New Länder                 | 7.9 (849)                        | 4.9 (485)  | -39      | 4.1 (446)                          | 3.0 (305)  | -26      | 3.7 (403)                              | 1.8 (179)  | -52      |
| Old Länder                 | 6.7 (4862)                       | 4.9 (3466) | -28      | 3.4 (2455)                         | 2.9 (2045) | -15      | 3.3 (2407)                             | 2.0 (1421) | -40      |

\* Number of deaths.

**Table 1** Infant, neonatal and postneonatal mortality in Germany by region: 1991 and 1997



**Figure 2** Infant mortality in Germany by region, 1991 and 1997

| Land                       | Slope ( $\beta$ ) 1991–97 | (95 % CI)        | P-value |
|----------------------------|---------------------------|------------------|---------|
| East Berlin                | -0.116                    | (-0.126, -0.105) | < 0.001 |
| Mecklenburg-West Pomerania | -0.086                    | (-0.114, -0.058) | 0.029   |
| Saxony-Anhalt              | -0.085                    | (-0.103, -0.066) | 0.007   |
| Thuringia                  | -0.084                    | (-0.095, -0.073) | 0.001   |
| Brandenburg                | -0.075                    | (-0.091, -0.058) | 0.007   |
| Saxony                     | -0.063                    | (-0.074, -0.053) | 0.002   |
| North-Rhine Westphalia     | -0.058                    | (-0.066, -0.050) | 0.001   |
| Hessen                     | -0.058                    | (-0.067, -0.049) | 0.002   |
| Schleswig-Holstein         | -0.058                    | (-0.076, -0.039) | 0.030   |
| Rhineland-Palatine         | -0.053                    | (-0.061, -0.045) | 0.001   |
| West Berlin                | -0.051                    | (-0.066, -0.036) | 0.023   |
| Bavaria                    | -0.051                    | (-0.059, -0.042) | 0.002   |
| Baden-Württemberg          | -0.050                    | (-0.059, -0.042) | 0.002   |
| Lower Saxony               | -0.049                    | (-0.058, -0.041) | 0.002   |
| Hamburg                    | -0.036                    | (-0.059, -0.011) | 0.211   |
| Saarland                   | -0.028                    | (-0.045, -0.011) | 0.178   |
| Bremen                     | +0.019                    | (-0.001, +0.039) | 0.407   |
| New Länder                 | -0.080                    | (-0.085, -0.075) | < 0.001 |
| Old Länder                 | -0.052                    | (-0.057, -0.048) | < 0.001 |

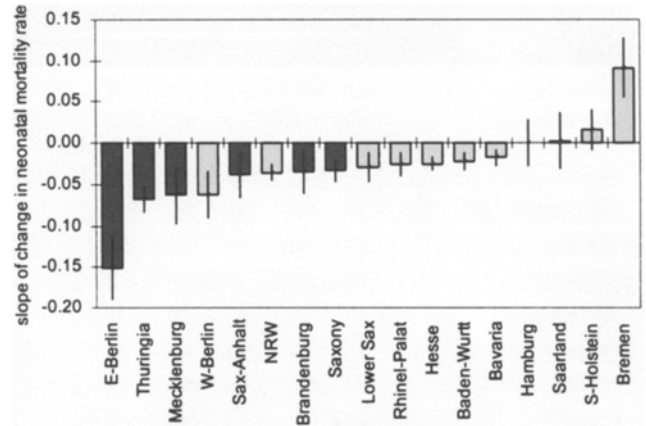
**Table 2** Changes in infant mortality in Germany by region: 1991–1997

*Neonatal mortality*

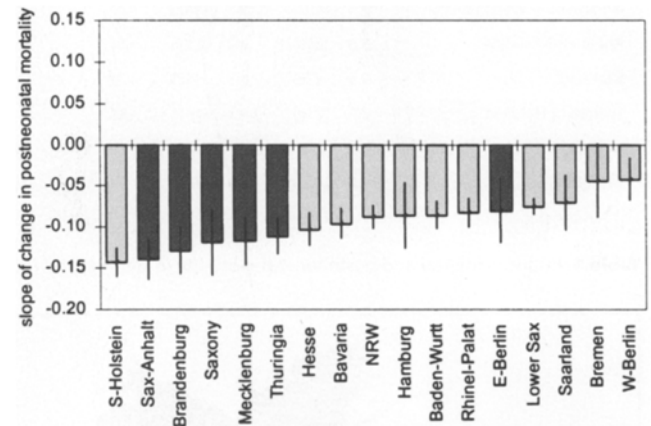
Although neonatal mortality in the five new Länder and east Berlin was generally higher than in the west, the western Länder North-Rhine Westphalia and Hamburg actually did worse than two eastern Länder, Brandenburg and Saxony (Tab. 1). This partly reflects the considerable variation in neonatal mortality in the former GDR. Between 1991 and 1997, neonatal mortality declined rapidly in the east, by up to 73%, but also in some western Länder, by up to 43%. Neonatal mortality did, however, show a small and statistically non-significant increase in three western Länder. Ranking the Länder according to the slope of the change reveals that the decline in neonatal mortality has been steeper in most eastern Länder (Fig. 3a). The slope of the overall decline in neonatal mortality in the east was twice that observed in the west and the difference was highly significant:  $\beta_{\text{east}}$ : -0.054 [95% CI: -0.063, -0.044] versus  $\beta_{\text{west}}$ : -0.025 [95% CI: -0.030, -0.020]. Thus, while the eastern Länder consistently experienced substantial improvements in neonatal mortality, so did some, but not all western Länder.

*Postneonatal mortality*

Postneonatal mortality fell in all Länder between 1991 and 1997. The percentage change ranged from 63% in Saxony to about 13% in east Berlin, with a decline by one-third or more in 14 out of 16 Länder (Tab. 1). Ranked according to the slope of decline, these figures form a fairly distinct east-west



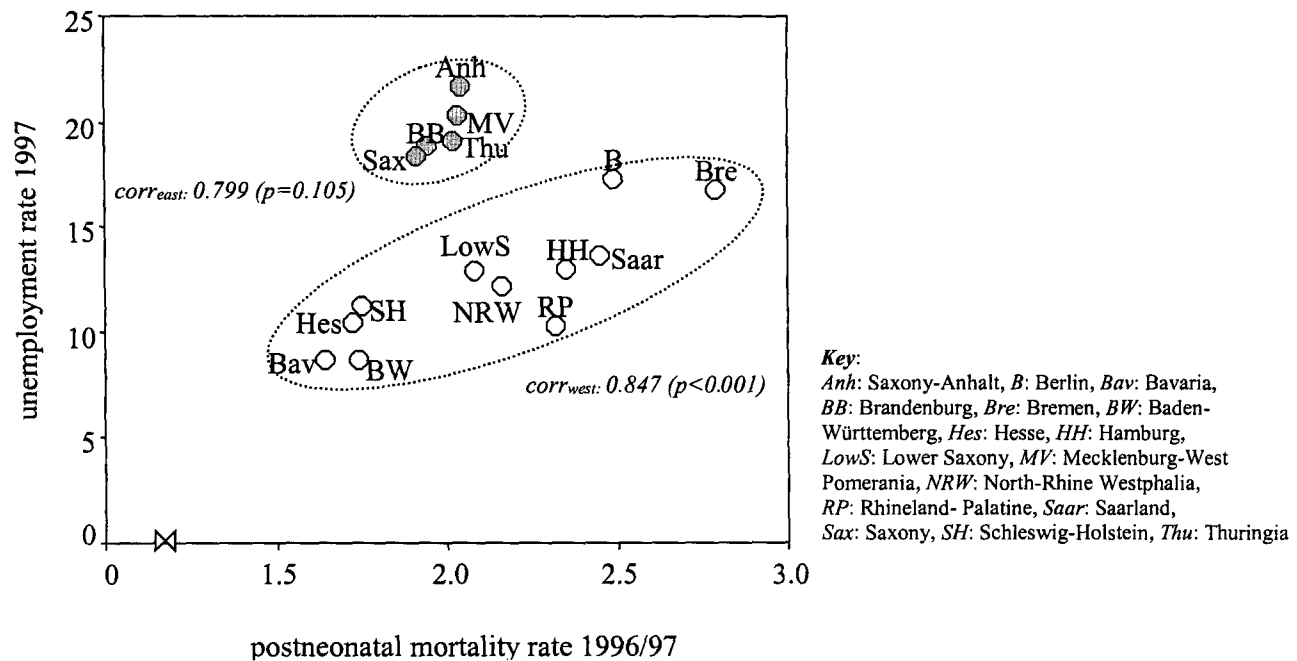
**Figure 3a** Slope ( $\beta$ ) of changes (incl. 95% confidence levels) in neonatal mortality in Germany by region between 1991 and 1997



**Figure 3b** Slope ( $\beta$ ) of changes (incl. 95% confidence levels) in postneonatal mortality in Germany by region between 1991 and 1997

demarcation, with all eastern Länder showing a steep and statistically significant decline in postneonatal mortality that was larger than in all western Länder:  $\beta_{\text{east}}$ : -0.116 [95% CI: -0.122, -0.109] versus  $\beta_{\text{west}}$ : -0.087 [95% CI: -0.098, -0.076] (Fig. 3b). The one exception is the northern-most Schleswig-Holstein, which displayed the steepest decline, at -0.143 ( $p < 0.001$ ). Overall, the slopes in both, the new and the old Länder were steeper than those observed for neonatal mortality.

Postneonatal mortality has frequently been shown to be related to socio-economic factors. We therefore examined its association with overall unemployment rates as an indicator for social variation at the Länder level. Correlating postneonatal mortality rates with unemployment rates (in % of labour force) for the year 1997<sup>14</sup> gives a significant positive association of 0.847 ( $p < 0.001$ ) for the west and a positive, but statically not significant association of 0.799 ( $p = 0.105$ ) for the east (Fig. 4).



**Figure 4** Scatter diagram showing the postneonatal mortality rate and unemployment rate for 1996/97 in Germany by region; east and west analysed separately

### Discussion

This study provides further insights into the health sequelae of German unification. It confirms earlier findings of substantial improvements in parameters of infant health in Germany in the 1990s at the regional level, at least when looking at aggregate measures such as infant mortality. However, it also shows that a simple east-west comparison of some parameters over time is likely to conceal a more complex regional pattern.

Between 1991 and 1997, infant mortality fell in all Länder except Bremen, with the decline being steepest in the eastern Länder and in east Berlin. This decline was largely attributable to a steep and significant decline in postneonatal mortality rather than neonatal mortality in both east and west. These results may appear somewhat surprising in view of our earlier study reporting that neonatal mortality declined more steeply in the east<sup>7</sup>. However, the analysis presented here concentrates on the 1991–1997 period only and thus omits the temporary increase in postneonatal mortality in the eastern Länder between 1990 and 1991 described earlier<sup>7</sup>.

There has been a considerable change from the initial east-west demarcation in infant mortality. By the end of the 1990s, a new pattern had emerged, with generally higher infant mortality in the north of Germany, in both east and west. The disappearance of the east-west divide was largely due to a rapid improvement in the east, resulting in infant mortality rates that were quite similar to those in the north-

western part. The improvements in the west, however, did not result in a disappearance of regional variation.

The reasons for the rapid improvement of indicators of infant health in the east have been discussed in detail<sup>7</sup>. We have previously shown that improvements in neonatal mortality in east Germany were largely attributable to improved survival at each birth weight, in particular among low and very low birth weight infants, accounting for an estimated 83% of the overall improvement between 1991 and 1996. Survival in this group is most amenable to medical intervention. This study confirms these findings indirectly at the regional level. Until 1994, the observed neonatal mortality in the east was significantly higher than would have been expected if birth weight specific neonatal mortality seen in the old Länder in those years had applied (data not shown). Assuming that changes in birth weight specific survival largely reflect the impact of neonatal care, this suggests that, had the medical care available in the west been available in these Länder between 1991 and 1994, neonatal mortality would have been substantially lower. From 1995, however, differences between observed and expected neonatal mortality were no longer significant, indicating a process of convergence between east and west in neonatal survival.

The improvements over time are likely to be explained by improvements in the quality of perinatal care as has been observed for the western part of Germany<sup>15,16</sup> and elsewhere<sup>6,17,18</sup>. Improvements included the implementation of the “Perinatal Quality Assurance Program” (*Perinatalerhe-*

bung) in all eastern Länder<sup>19</sup> from 1992. This program was originally introduced in Bavaria, west Germany, in 1975 and subsequently extended to the remaining western Länder. The program is believed to have contributed to the decline in perinatal and early neonatal mortality in the west in the 1980s by enhancing the quality of perinatal care. Data for the eastern Land Brandenburg showed an increase in the proportion of high risk pregnancies that were referred to hospital prior to delivery from 53% in 1992 to 61% in 1997<sup>20</sup>. There was also an increase in the proportion of pregnant women receiving routine cardiotocography (ante partum) recording, from 74% in 1992 to 92% in 1997, a marker of more intensive perinatal care<sup>19</sup>.

The steep decline in postneonatal mortality has probably to be explained differently for the eastern and the western Länder. In the east, the rapid improvement in postneonatal mortality is likely to reflect a recovery from the temporary mortality increase immediately after unification. This increase has been attributed, in part, to the reorganisation of the system of infant care in the new Länder, although the immediate consequences of transition in terms of economic downturn and insecurity may have affected rates as well<sup>7</sup>. In the west, on the other hand, improvements are likely to be partly due to a substantial decline in mortality from sudden infant death syndrome, following regional campaigns in advice on sleeping position in 1991<sup>21,22</sup>.

Regional variation in infant mortality in Germany is not a new phenomenon. Available evidence indicates that, in the west, there was a north-south gradient in the 1970s and especially in the 1980s<sup>23,24,25</sup>. A similar result has been shown for life expectancy as well<sup>26</sup>. Relatively higher levels of infant mortality were also reported for the north-central part of the former GDR in the 1980s compared with the low-mortality regions in the south<sup>24</sup> that also had highest life expectancy<sup>27</sup>. The explanations for the regional differences in infant mortality put forward so far have been very general and more research is needed. The variation in the west has been attributed, largely, to differences in socioeconomic conditions such

as income, labour market and education. In the east, higher levels of industrialisation and urbanisation in the south were suggested to have been related to a qualitatively higher level of socio-economic well-being compared to the more rural areas in the north, resulting in the observed regional differences in key health indicators<sup>28</sup>.

From this analysis it emerges that the considerable regional diversity in infant mortality is largely determined by post-neonatal mortality rather than neonatal mortality. As post-neonatal mortality has been shown to be related to socio-economic factors, the results point to the importance of socio-economic conditions in shaping the health status of the German population at the regional level. In fact, correlating postneonatal mortality rates with overall unemployment rates for the west in 1997 gives a significant positive association (Fig. 4). A similar trend was observed for the east, although, however, the number of points is too small to permit a meaningful analysis.

## Conclusion

These findings have important implications for policy. Although all Länder experienced substantial improvements in neonatal and postneonatal mortality in the 1990s, considerable regional variation remains within the country, suggesting that there is still scope for further improvements in some Länder. With regard to neonatal mortality, further action is needed most in the eastern Länder as well as the western Länder Hamburg, Bremen, and Saarland. Although this is the first attempt to study systematically regional variation in infant mortality in Germany, the level of analysis may still conceal sub-regional differences, as there is certainly a potential for further improvement even within the individual Länder.

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## Zusammenfassung

### Regionale Variation der Säuglingssterblichkeit in Deutschland

**Fragestellung:** Seit der Vereinigung im Jahr 1990 haben die beiden Teile Deutschlands einen komplexen Prozess in Bezug auf Säuglingssterblichkeit durchlaufen, wobei das Muster dieses Wandels in Ost und West verschieden war. Die vorliegende Studie untersucht, inwieweit diese Unterschiede Heterogenität auf regionaler Ebene maskieren.

**Methoden:** Analyse von Routinedaten zur Säuglings-, neonatalen und postneonatalen Sterblichkeit in den 16 Bundesländern im Zeitraum 1991 bis 1997. Als Analyseinstrument kommt ein log-lineares Regressionsmodell zur Anwendung.

**Ergebnisse:** Im Jahr 1991 war die Säuglingssterblichkeit in fast allen neuen Bundesländern höher als in den alten Ländern. Dieser Ost-West-Gradient hat sich jedoch zum Jahr 1997 aufgelöst, wobei die Säuglingssterblichkeit mit einer Ausnahme in allen Ländern über den genannten Zeitraum zurückgegangen ist. Mit einer Verminderung um 31% bis 52% war dieser Prozess in den in den neuen Ländern am deutlichsten ausgeprägt. Rückgänge der Säuglingssterblichkeit waren bedingt durch Verbesserungen der neonatalen wie auch der postneonatalen Sterblichkeit.

**Schlussfolgerungen:** Zum Zeitpunkt der Vereinigung bestand ein deutlicher Ost-West-Gradient in der Säuglingssterblichkeit, 1997 jedoch nicht mehr. In Deutschland besteht nach wie vor eine deutliche regionale Variation in der Säuglingssterblichkeit, die vor allem durch Unterschiede in der postneonatalen Sterblichkeit bedingt ist.

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## Résumé

### Variations temporelles et régionales du taux de mortalité infantile après l'unification allemande

**Objectifs:** Après leur réunification en 1990, les deux parties de l'Allemagne ont subi un processus complexe qui a fait convergé leurs taux de mortalité infantile. Les types de changements ont toutefois varié entre l'Est et l'Ouest. Cette étude investigate si ce phénomène dissimule un modèle complexe de différences régionales.

**Méthodes:** Examen de statistiques de routine de mortalité infantile, néonatale, postnéonatale. Les variations observées entre 1991–1997 dans les 16 états fédéraux d'Allemagne (Länder) ont été étudiées par régression linéaire.

**Résultats:** En 1991, la mortalité infantile était plus élevée dans presque tous les Länder de l'Est que dans ceux de l'Ouest. En 1997, cet écart avait disparu. Pendant cette période, la mortalité infantile avait chuté dans 15 Länder. Le déclin était plus marqué dans l'Est (31–51%). Les améliorations s'expliquent principalement par une diminution marquée de la mortalité néonatale et postnéonatale.

**Conclusions:** Au moment de l'unification, il existait une démarcation Est-Ouest importante, mais celle-ci a disparu avant 1997. Toutefois, des variations régionales importantes dans la mortalité infantile demeurent et s'expliquent par des différences au niveau de la mortalité postnéonatale.

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