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# Mortality among twins and singletons in sub-Saharan Africa between 1995 and 2014: a pooled analysis of data from 90 Demographic and Health Surveys in 30 countries



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## Summary

**Background** Sub-Saharan Africa has the world's highest under-5 and neonatal mortality rates as well as the highest naturally occurring twin rates. Twin pregnancies carry high risk for children and mothers. Under-5 mortality has declined in sub-Saharan Africa over the last decades. It is unknown whether twins have shared in this reduction.

**Methods** We pooled data from 90 Demographic and Health Surveys for 30 sub-Saharan Africa countries on births reported between 1995 and 2014. We used information on 1 685 110 singleton and 56 597 twin livebirths to compute trends in mortality rates for singletons and twins. We examined whether the twin–singleton rate ratio can be attributed to biological, socioeconomic, care-related factors, or birth size, and estimated the mortality burden among sub-Saharan African twins.

**Findings** Under-5 mortality among twins has declined from 327.7 (95% CI 312.0–343.5) per 1000 livebirths in 1995–2001 to 213.0 (196.7–229.2) in 2009–14. This decline of 35.0% was much less steep than the 50.6% reduction among singletons (from 128.6 [95% CI 126.4–130.8] per 1000 livebirths in 1995–2001 to 63.5 [61.6–65.3] in 2009–14). Twins account for an increasing share of under-5 deaths in sub-Saharan Africa: currently 10.7% of under-5 mortality and 15.1% of neonatal mortality. We estimated that about 315 000 twins (uncertainty interval 289 000–343 000) die in sub-Saharan Africa each year. Excess twin mortality cannot be explained by common risk factors for under-5 mortality, including birthweight. The difference with singletons was especially stark for neonatal mortality (rate ratio 5.0, 95% CI 4.5–5.6). 51.7% of women pregnant with twins reported receiving medical assistance at birth.

**Interpretation** The fate of twins in sub-Saharan Africa is lagging behind that of singletons. An alarming one-fifth of twins in the region dies before age 5 years, three times the mortality rate among singletons. Twins account for a substantial and growing share of under-5 and neonatal mortality, but they are largely neglected in the literature. Coordinated action is required to improve the situation of this extremely vulnerable group.

**Funding** None.

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## Introduction

Sub-Saharan Africa has the highest rate of naturally occurring twin births in the world.<sup>1</sup> Whereas natural twinning rates are about six to nine twin births per 1000 maternities in east Asia and Latin America, and eight to 16 in Europe, North America, and the Middle East, they are as high as 18 per 1000 or more in the central African twinning zone that runs from Guinea, Liberia, and Côte d'Ivoire in the west of Africa to Tanzania, Mozambique, and the Comoros in the east.<sup>1</sup> About 3–4% of children born in sub-Saharan Africa are members of a twin pair.

Twins are extremely vulnerable and twin births and twin pregnancies have a high risk of complications for mother and child. Twins suffer from low birthweight and preterm delivery. Twin pregnancies and births are associated with obstetric complications such as anaemia, post-partum haemorrhage, hypertensive disorders, and increased maternal mortality.<sup>2–4</sup> Under-5 and neonatal mortality rates are two to five times higher than among

twins compared with the largest relative differences found in regions with the lowest mortality rates.<sup>5–10</sup> For example, in Finland, which has one of the lowest infant mortality rates in the world, infant mortality among multiple births is considerably higher than among singletons (11.1 vs 1.9 deaths per 1000 livebirths in the period 2010–15; Ahokas E, Population Statistics, Statistics Finland, personal communication). Twins suffer more from congenital malformations and could also therefore be more vulnerable after the first year of life.<sup>9</sup>

The fate of twins might be particularly precarious in sub-Saharan Africa where child mortality rates are the highest in the world,<sup>11</sup> where maternal and newborn care is weak,<sup>11–14</sup> and where the absolute number of children under 5 years, including twins, will increase by about 20% over the next decades.<sup>15</sup> High mortality rates among twins have been documented for many sub-Saharan sites or countries, with under-5 mortality rates ranging from over 200 to almost 400 deaths per 1000 livebirths.<sup>5,6,16,17</sup> Also, maternal mortality and morbidity associated with

*Lancet Glob Health* 2017;

S: e673–79

Published Online

May 31, 2017

[http://dx.doi.org/10.1016/S2214-109X\(17\)30197-3](http://dx.doi.org/10.1016/S2214-109X(17)30197-3)

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**Research in context****Evidence before this study**

We searched PubMed for studies from inception until Dec 1, 2016, with combinations of search terms including “twins”, “multiple pregnancies”, “multiple births”, “multiple-gestation”, “multifetal pregnancies”, “under-5 mortality”, “neonatal mortality”, “infant mortality”, “child mortality”, “Africa”, and country names. We did not restrict the search by language. Studies identified were mostly hospital-based studies of twin births and the complications surrounding those births, including child mortality and maternal mortality and morbidity. Three comparative studies were identified in which twin mortality rates were calculated for two or more sub-Saharan African countries. We found no studies reporting trends over time, nor studies estimating the total mortality burden among twins in sub-Saharan Africa. Studies indicated that twins suffer from lower birthweight and preterm delivery and have much higher under-5 and neonatal mortality than singletons. Under-5 mortality rates among twins ranged from over 200 to almost 400 per 1000 livebirths.

**Added value of this study**

Our trend study shows that between 1995 and 2014, under-5 mortality and neonatal mortality have decreased much less among twins (35.0%) than among singletons (50.6%). The twin-singleton rate ratio for under-5 mortality has increased from 2.5 to 3.4 and for neonatal mortality from 4.6 to 5.0. Twins account for 10.7% of all under-5 deaths and 15.1% of neonatal deaths in the region and these percentages are increasing. The total number of twins dying before 5 years of age is estimated at about 315 000 per year.

**Implications of all the available evidence**

Given the high and increasing proportion of under-5 and neonatal mortality in sub-Saharan Africa due to mortality among twins, it will be difficult to achieve the Every Newborn 2035 target and the Sustainable Development Goal target regarding neonatal and under-5 mortality without special attention to this highly vulnerable group.

twin pregnancies are very high in sub-Saharan Africa.<sup>2,4</sup> Although effective guidelines are available for antenatal and delivery care for twins,<sup>18,19</sup> many women in the region receive little antenatal care at all and deliver in a non-medical setting.<sup>5,17</sup> Given the high absolute number of twin births in sub-Saharan Africa, in combination with the high perinatal and maternal mortality surrounding these births, it might be difficult, without special attention to this vulnerable group, to achieve the Every Newborn 2035 target of fewer than ten neonatal deaths per 1000 livebirths<sup>20</sup> and the Sustainable Development Goal (SDG) 2030 targets of fewer than 12 per 1000 neonatal deaths and fewer than 25 per 1000 under-5 deaths. Moreover, the literature surrounding these targets<sup>12,21–25</sup> does not discuss twin births or the special care twins and their mothers require. In the 2015 SDG Indicators and Monitoring Framework,<sup>26</sup> twins are not mentioned.

The gap in knowledge is particularly pertinent with regard to trends. We know that between 1990 and 2015, under-5 mortality in sub-Saharan Africa has decreased by more than half (54%).<sup>27</sup> However, it is not clear to what extent this improvement has been experienced by twins. No trend studies are available that track the development of twin mortality in sub-Saharan Africa. Also, the size of the problem of twin excess mortality in sub-Saharan Africa is unknown. To change this situation, we assembled data on 1.6 million births, including 56 597 twin births, derived from 90 Demographic and Health Surveys (DHS) held between 1995 and 2015 in 30 sub-Saharan African countries. First, we examine how twin mortality has developed over time compared with singleton mortality. Second, we determine to what extent singletons and twins in sub-Saharan Africa differ with

regard to common sociodemographic determinants of under-5 mortality. Third, we assess to what extent excess twin mortality can be explained by these socio-demographic factors. Finally, we estimate the total mortality burden among twins in sub-Saharan Africa.

**Methods****Study design**

The data are derived from the DHS Program. Each DHS survey consists of a household survey and separate women's survey. In the latter, all usual resident women aged 15–49 years are invited for an interview, which includes a complete birth history collecting information on all livebirths of the women, including date of birth, sex of the child, whether it was a singleton or multiple birth, and whether and when a child died. The team executing the DHS survey ensures protection of participants in agreement with local and international laws.

**Procedures**

We pooled 90 standard DHS surveys done between 1995 and 2015 in 30 sub-Saharan African countries: Benin, Burkina Faso, Burundi, Cameroon, Chad, Comoros, Democratic Republic of Congo, Republic of Congo, Côte d'Ivoire, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Liberia, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. These countries were selected because their DHS survey provided sufficient numbers of births in the following periods: 1995–2001, 2002–08, and 2009–14. These 30 countries account for 83% of all under-5 mortality in sub-Saharan Africa (appendix).<sup>11</sup> We selected all children born in the period 1995–2014. DHS do not record stillborn children.

For more on the **Demographic and Health Surveys Program** see <https://dhsprogram.com>

For more on the **Sustainable Development Goals** see <https://sustainabledevelopment.un.org>

See [Online](#) for appendix

All figures refer to livebirths and for twins this means only those cases where both twins were liveborn. Triplets and other higher order multiple births were excluded. Marital status, place of residence, and wealth were measured at the time of interview. Household wealth was measured by the International Wealth Index,<sup>28</sup> which is a cross-nationally comparable index based on the household's possession of consumer durables, housing quality, and access to basic amenities.

### Statistical analysis

To assess to what extent excess twin mortality can be accounted for by differences in biological and socioeconomic factors, medical assistance, and birth size, the 2009–14 mortality rate ratios were adjusted in a series of regression models. We included the following variables: maternal age at birth (in years), birth order, length of the preceding birth interval (in months), mother's marital status, urban or rural residence, household wealth, place of delivery (in a medical facility or clinic versus at home or other non-medical location), and assistance of a nurse, medically trained midwife, or doctor during delivery. Women were asked to report whether their child's size at birth was very small, small, average, large, or very large. This metric has been shown to be a good proxy for birthweight.<sup>29</sup> For the case observations with missing information for one or more variables of interest, results were estimated with multiple imputations (MI command in Stata).

For these multivariate analyses, we restricted the sample to births that occurred not more than 5 years before the interview because questions about the place of delivery and medical assistance at delivery were only asked for the three most recent births in the last 5 years. All models included fixed effects for 323 subnational regions to account for measured and unmeasured regional context factors. Regions correspond to administrative divisions in the 30 countries. There are between three and 21 regions per country. Fixed birth year effects were also included.

Adjusted mortality rate ratios were calculated using Poisson regression. In all analyses we used a combination of weights: DHS household weights to take into account the survey nature of the data and weights for the relative population size of the country to make the results representative for the collective of 30 sub-Saharan African countries. Population data were taken from the World Bank's World Development Indicators. Analyses were done in Stata 14 using the svy estimation command for complex survey data.<sup>30</sup> All our conclusions hold true for unweighted estimation as well.

### Role of the funding source

This study was not funded by any grant or funding body. Both authors had full access to all data and the corresponding author had final responsibility for the decision to submit for publication.

## Results

The total 1995–2014 sample included information on 1685110 children, of which 56597 were twins. 190642 children died before age 5 years, of which 16399 were twins. Table 1 presents crude under-5 mortality rates for singletons and twins for the three periods, 1995–2001, 2002–08, and 2009–14. There was a reduction in under-5 mortality for both singletons and twins between 1995 and 2014. For singletons, under-5 mortality decreased by 51%, from 128.6 to 63.5 per 1000 livebirths. This result is similar to the UN estimate of a 54% reduction in overall under-5 mortality between 1990 and 2015 for sub-Saharan Africa as a whole.<sup>11</sup>

Among twins, the reduction in under-5 mortality from 327.7 to 213.0 per 1000 is much larger than among singletons in absolute terms (a reduction of 114.5 vs 65.5 deaths per 1000), but it is smaller in relative terms (35% vs 51%). Twins experienced 198.8 more deaths per 1000 livebirths than singletons in 1995–2001, but this excess mortality decreased to 149.5 per 1000 in the 2009–14 period. So, the absolute difference in mortality rates between twins and singletons has fallen by a quarter.

The rate ratio for the difference in under-5 mortality between twins and singletons increased over the study period from 2.5 (95% CI 2.4–2.7) to 3.4 (3.1–3.6), an increase of 32%. Also, the share of twins in total under-5 mortality has increased substantially. Whereas in 1995–2001, 8.1% (95% CI 7.6–8.5) of under-5 mortality was due to mortality among twins, in 2009–14 this was 10.7% (9.8–11.6) of total mortality. The number of

For more on the World Bank's World Development Indicators see <http://data.worldbank.org/wdi>

	1995–2001	2002–08	2009–14	Change from 1995–2001 to 2009–14
<b>Singletons</b>				
Livebirths	735 849	641 995	250 669	..
Deaths	94 601	63 731	15 912	..
Mortality rate per 1000 (95% CI)	128.6 (126.4–130.8)	99.3 (97.5–101.0)	63.5 (61.6–65.3)	–50.6%
<b>Twins</b>				
Livebirths	25 324	22 349	8924	..
Deaths	8299	6199	1900	..
Mortality rate per 1000 (95% CI)	327.7 (312.0–343.5)	277.4 (264.8–290.0)	213.0 (196.7–229.2)	–35.0%
Absolute twin-singleton difference	199.2	178.1	149.5	–24.9%
Twin-singleton rate ratio (95% CI)	2.5 (2.4–2.7)	2.8 (2.7–2.9)	3.4 (3.1–3.6)	31.6%
Share of twins in total under-5 mortality (95% CI)	8.1% (7.6–8.5)	8.9% (8.4–9.3)	10.7% (9.8–11.6)	32.3%
Countries: Benin, Burkina Faso, Burundi, Cameroon, Chad, Comoros, Democratic Republic of Congo, Republic of the Congo, Côte d'Ivoire, Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Lesotho, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.				

Table 1: Under-5 mortality among singletons and twins in 30 countries in sub-Saharan Africa 1995–2014

	1995–2001	2002–08	2009–14	Change from 1995–2001 to 2009–14
<b>Neonatal (&lt;1 month)</b>				
Singletons	36.9 (35.8–38.0)	32.0 (31.1–33.0)	27.5 (26.2–28.7)	–25.6%
Twins	171.7 (159.3–184.2)	150.1 (139.5–160.6)	137.0 (122.2–151.8)	–20.2%
Twin–singleton rate ratio	4.6 (4.3–5.0)	4.7 (4.3–5.0)	5.0 (4.4–5.6)	7.3%
<b>Post-neonatal (1–11 months)</b>				
Singletons	45.2 (44.0–46.4)	33.7 (32.7–34.6)	21.8 (20.8–22.8)	–51.8%
Twins	117.6 (106.0–129.2)	89.3 (81.5–97.1)	57.2 (48.1–66.4)	–51.3%
Twin–singleton rate ratio	2.6 (2.4–2.9)	2.7 (2.4–2.9)	2.6 (2.2–3.1)	0.9%
<b>Child (12–59 months)</b>				
Singletons	60.3 (58.6–62.0)	42.7 (41.5–43.8)	22.0 (20.8–23.2)	–63.5%
Twins	93.6 (81.9–105.3)	77.3 (68.8–85.9)	45.7 (34.3–57.0)	–51.2%
Twin–singleton rate ratio	1.6 (1.4–1.8)	1.8 (1.6–2.0)	2.1 (1.6–2.7)	33.8%

Data in parentheses are 95% CI. Post-neonatal mortality rates per 1000 surviving the first month; child mortality rates per 1000 surviving the first year of life.

**Table 2: Mortality rates for neonatal, post-neonatal, and child mortality among singletons and twins in 30 countries in sub-Saharan Africa 1995–2014**

under-5 deaths in sub-Saharan Africa in 2015 was estimated at 2.9 million by the UN Inter-agency Group for Child Mortality Estimation.<sup>11,27</sup> This number translates to about 315 000 twins (uncertainty interval 289 000–343 000) dying before their fifth birthday (appendix).

In table 2 we break down under-5 mortality into mortality at different stages (conditional on survival to that age). The major difference in mortality between singletons and twins occurred in the first days and month of life. In the most recent period, the twin–singleton rate ratio for neonatal mortality was 5.0 (95% CI 4.4–5.6), whereas it was 2.6 (2.2–3.1) for post-neonatal mortality (1–11 months) and 2.1 (1.6–2.7) for child mortality (12–59 months). The neonatal mortality rate has decreased for both twins and singletons, but for twins is still exceptionally high (137.0 per 1000). Although the biggest difference between twins and singletons was observed in the first month of life, the rate ratio for child mortality implies that after 12 months—and presumably highly selective mortality—twins still experienced a mortality rate twice as high as singletons.

Among both twins and singletons, the share of neonatal mortality in total under-5 mortality increased over the three periods. By 2009–14, neonatal mortality was responsible for 43% (27.5 of 63.5 per 1000) of under-5 mortality among singletons and for 64% (137.0 of 213.0 per 1000) among twins. Our figures show that in the 2009–14 period, as much as 15.1% (95% CI 13.5–16.8) of all neonatal deaths in sub-Saharan Africa were accounted for by twins.

Table 3 shows the distribution by twins and singletons of common demographic, socioeconomic, and medical care

factors that are associated with under-5 mortality. Twins and singletons did not differ much in household wealth, maternal education, or marital status of the mother. Due to the large sample size all of the above differences are significant at the 5% level but none of them are substantial in absolute size. This result was also true for the difference in sex of the child and mother's urban or rural place of residence.

Larger differences were found with birth order and mother's age at birth (table 3). Twin births were less frequent among first births (6.8% vs 20.9%) and more frequent among high parity births of four or more (66.6% vs 45.4%). They were also less frequent among mothers aged 12–19 years (7.9% vs 18.9%) and more frequent among mothers in their 30s (35.0% vs 25.2%). In multivariate models, parity and maternal age have independent positive associations with twin births (appendix). These results are in agreement with findings from studies in more developed countries.<sup>31</sup>

Twins were more likely than singletons to have been born in a medical setting (62.5% vs 52.7%) and to have had some medical assistance at birth (51.7% vs 40.4%). These associations might have been to the benefit of twins, but with regard to birth size they were disadvantaged. More than one in three (35.6%) twins was reported to be smaller than average, compared with only one in six singletons (16.8%).

Of the 259 593 observations in the 2009–14 period for which multivariate analyses were done, 33 228 (12.8%) of the case observations had missing information for one or more variables of interest. Missing information on marital status (17 846 [6.9%]) or on child's size at birth (25 186 [9.7%]) were most common. Results estimated with multiple imputations are similar to those of the complete case analysis (appendix). In the base model, which included only the fixed effects, the twin–singleton rate ratios for under-5 and neonatal mortality were 3.4 (95% CI 3.1–3.7) and 5.0 (4.5–5.7), respectively (table 4). After adjusting for demographic and socioeconomic factors, these rate ratios increased to 3.6 (95% CI 3.3–3.9) and 5.6 (4.9–6.3). Additional controls for medical assistance showed little change in rate ratios, but additional adjustment for birth size reduced the twin–singleton rate ratios back to base level for both under-5 mortality (rate ratio 3.4, 95% CI 3.1–3.7) and neonatal mortality (rate ratio 5.0, 4.4–5.7).

Although table 3 shows that twins were much more likely to have small birth size, this could not explain excess mortality among twins. The twin–singleton rate ratio for under-5 mortality rate ranged from 2.9 (95% CI 2.3–3.7) among very small children to 3.7 (2.8–5.0) among very large ones (appendix). This result is in line with the so-called birthweight paradox, the finding that babies with low birthweight in high-risk populations, such as twins, have lower mortality than babies with low birthweight in more favourable populations.<sup>32,33</sup> Among

	Singletons (N=218 483)		Twins (N=7318)	
	n (%)	Under-5 mortality rate (per 1000)	n (%)	Under-5 mortality rate (per 1000)
<b>Household wealth</b>				
Poorest quartile	58 088 (26.6%)	71.4	1732 (23.7%)	230.3
Second	50 802 (23.3%)	68.8	1797 (24.6%)	250.3
Third	53 605 (24.5%)	56.4	1820 (24.9%)	169.1
Wealthiest quartile	55 988 (25.6%)	48.6	1968 (26.9%)	176.7
<b>Mother's education</b>				
No education	91 641 (41.9%)	70.5	3054 (41.7%)	239.6
(Some) primary	71 426 (32.7%)	60.5	2315 (31.6%)	195.7
Secondary or more	55 416 (25.4%)	47.2	1948 (26.6%)	163.8
<b>Marital status</b>				
Not married	21 152 (9.7%)	66.0	604 (8.3%)	238.0
Monogamous marriage	149 132 (68.3%)	55.6	4939 (67.5%)	195.4
Polygamous, one other wife	39 471 (18.1%)	72.6	1477 (20.2%)	210.2
Polygamous, more than two wives	8 728 (4.0%)	79.9	297 (4.1%)	284.7
<b>Urban residence</b>				
No	155 422 (71.1%)	65.4	4998 (68.3%)	222.9
Yes	63 031 (28.9%)	51.2	2319 (31.7%)	168.1
<b>Sex</b>				
Girls	107 861 (49.4%)	56.1	3523 (48.1%)	173.5
Boys	110 622 (50.6%)	66.4	3794 (51.9%)	235.3
<b>Birth order</b>				
1	45 574 (20.9%)	67.5	499 (6.8%)	325.2
2-3	73 776 (33.8%)	53.8	1942 (26.5%)	195.2
4+	99 133 (45.4%)	64.1	4876 (66.6%)	197.4
<b>Mother's age at birth (years)</b>				
12-19	41 207 (18.9%)	74.6	581 (7.9%)	326.2
20-29	114 781 (52.5%)	56.1	3866 (52.8%)	203.1
30-39	55 013 (25.2%)	59.3	2561 (35.0%)	178.5
40-49	7 482 (3.4%)	82.8	309 (4.2%)	232.3

(Table 3 continues in next column)

twins of average size or larger, the under-5 mortality rate was still 186.1 per 1000.

	Singletons (N=218 483)		Twins (N=7318)	
	n (%)	Under-5 mortality rate (per 1000)	n (%)	Under-5 mortality rate (per 1000)
(Continued from previous column)				
<b>Place of delivery</b>				
At home	103 371 (47.3%)	72.4	2747 (37.5%)	250.9
Some type of clinic	115 112 (52.7%)	51.4	4570 (62.5%)	178.2
<b>Medical assistance at birth</b>				
None	130 118 (59.6%)	68.7	3537 (48.3%)	240.7
Nurse, midwife, or doctor	88 365 (40.4%)	50.4	3780 (51.7%)	172.6
<b>Size at birth</b>				
Very small	13 530 (6.2%)	63.8	910 (12.4%)	226.9
Small	23 206 (10.6%)	57.7	1693 (23.1%)	187.4
Average	92 052 (42.1%)	55.9	2858 (39.1%)	178.7
Large	59 707 (27.3%)	71.6	1382 (18.9%)	213.0
Very large	29 988 (13.7%)	90.5	474 (6.5%)	292.3

**Table 3: Distribution of demographic, socioeconomic, and medical factors in singletons and twins in 2009-14**

	Under 5 (0-59 months)	Neonatal (0 months)
Base model	3.4 (3.1-3.7)	5.0 (4.5-5.7)
Plus demographic factors	3.5 (3.2-3.9)	5.5 (4.9-6.3)
Plus socioeconomic factors	3.6 (3.3-3.9)	5.6 (4.9-6.3)
Plus medical assistance	3.6 (3.3-3.9)	5.6 (4.9-6.3)
Plus birth size	3.4 (3.1-3.7)	5.0 (4.4-5.7)

Data are rate ratios (95% CI). Weighting described in the Methods. Base model: fixed country effects, fixed year effects. Biological factors: sex, birth order, birth order squared, preceding birth interval, preceding birth interval squared, mother's age at birth, mother's age at birth squared. Socioeconomic factors: maternal education, household wealth, urban residence, mother's partner status, and marriage. Medical factors: delivery at a clinic and assistance at delivery.

**Table 4: Twin-singleton rate ratios adjusted for major risk factors, 2009-14**

## Discussion

This study is the first comprehensive analysis on trends in twin mortality in sub-Saharan Africa. Under-5 mortality has decreased substantially in this region over the past decades. Nevertheless, the UN Inter-agency Group for Child Mortality Estimation has estimated that 2.9 million children in the region died before the age of 5 years in 2015.<sup>11</sup> Our analysis indicates that almost 11% (about 315 000) of these deaths occurred among twins. This proportion has risen from 8% in 1995-2001. The differences are even larger for neonatal mortality. In

2009–14, the rate ratio of twin versus singleton neonatal mortality was 5·0 and the share of twins in total neonatal mortality was 15%.

Before discussing the practical implications of our findings, we should address some data limitations. Our estimates of twin mortality are likely to be lower bound estimates. The main limitation of the DHS for this study is possible under-reporting of twin births and twin deaths. Women who died during or since childbirth cannot be interviewed. Since the probability of maternal mortality is higher with twin births,<sup>2,4</sup> it is likely that DHS data underestimate the number of twin births and deaths. Moreover, there might be further under-reporting of twin births and twin mortality because only livebirths are registered in the DHS surveys and all twin births in the data consist of two liveborn children. Where one of the twins was stillborn, the surviving co-twin has most likely been registered as a singleton. Because of the higher mortality risk inherent in twins, it is likely that the surviving co-twin faces a higher mortality risk than singletons (as has been reported for Burkina Faso<sup>17</sup>). Sear and colleagues<sup>34</sup> report higher stillbirth rates among twins in Gambia and higher neonatal mortality among liveborn twins. DHS data are based on recall information, which makes them potentially susceptible to recall bias. However, births and deaths of children are among the most salient and emotional life events in women's lives and therefore recall bias is unlikely to be high. Again, recall bias is more likely to suppress rather than increase estimates of twin mortality.

To reduce twin mortality in sub-Saharan Africa, improvements in health-care services are needed in all three phases of the process: during pregnancy, at delivery, and post partum.<sup>17</sup> First, early detection of twin pregnancies, good antenatal care tailored towards the needs of mothers pregnant with twins, and timely referral for hospital delivery are important preconditions for twin survival and maternal health during and after delivery.<sup>5,35,36</sup> However, still too few women pregnant with twins in the region receive appropriate medical care.<sup>5,37</sup> For example, almost half of the women giving birth to twins in a Nigerian tertiary hospital did not receive antenatal care<sup>35</sup> and of the mothers who delivered twins in a study hospital in Guinea Bissau, as many as 65% were not aware that they were pregnant with twins.<sup>5</sup> A first recommendation therefore is to strengthen antenatal care services and train providers of this care in recognising twin pregnancies. If ultrasound is lacking, most twin cases can be identified by clinical examination.<sup>5,38</sup> When twin pregnancies are identified, the mothers should receive antenatal care that, given the often resource poor environments they live in, is as much as possible in line with existing guidelines for twin pregnancies.<sup>18,19,36</sup>

Second, it is important that delivery should take place in a hospital setting with staff trained in twin deliveries and with facilities for interventions, including caesarean

section.<sup>5,35</sup> Twins are a high-risk group, associated with preterm delivery and complications such as post-partum haemorrhage and increased maternal mortality.<sup>2–4,35</sup> Twin deliveries have a substantially increased risk of caesarean section.<sup>2</sup> In our data for the 2009–14 period, the crude under-5 mortality rate for twins was 178·2 per 1000 among deliveries that took place in a medical setting compared with 250·9 per 1000 among deliveries at home. Given that almost half of these twin births took place without assistance of a medically trained person, and that many hospital deliveries in sub-Saharan Africa are last minute or emergency cases,<sup>5,35</sup> there is still much to gain.

Third, special attention for twin births in sub-Saharan Africa should continue after a safe delivery. Mortality rates of twins remain high after the perinatal period and twins have increased risk of other complications, such as neurodevelopmental disabilities and congenital malformations.<sup>9,39</sup> Therefore, it would be advisable to monitor these children in their first years of life. Particularly vulnerable are twins born after a short birth interval, from poor families, with an older mother, or when one child of a twin pair has died.<sup>5,6,17</sup>

If the care for twins and women pregnant with twins does not improve considerably in the coming years, the absolute numbers of twin deaths will hardly decrease. At the current speed of improved survival among twins, the reduction in the number of deaths will be compensated to a large extent by the growth in the under-5 population in the region, which is expected to increase by about 20% until 2030.<sup>15</sup> To achieve the SDG and Every Newborn targets regarding neonatal and under-5 mortality, more attention will have to be paid to twin pregnancies and twin births. Despite twins' higher vulnerability, it is possible to achieve high survival and, as the Finnish case shows (Ahokas E, Population Statistics, Statistics Finland, personal communication), a high twin–singleton mortality ratio can co-exist with small absolute mortality differences between twins and singletons. Although it is unrealistic to expect Finnish mortality rates for sub-Saharan Africa anytime soon, the positive message is that improvements in care for twin pregnancies and twin births do not require unusual or new measures or technology. The potential for improvements in the survival of this forgotten group of vulnerable newborns is large and starts with increasing awareness of its plight.

#### Contributors

CWSM and JS conceived the study, made equal contributions to the study, analysed the data, wrote, and approved the final manuscript.

#### Declaration of interests

We declare no competing interests.

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