

## What are the odds?

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## What are the odds? Interpretation of odds ratios from a logistic regression model

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### Learning points

- Logistic regression analysis is used for binary outcome data (e.g. maternal death) to model associations with multiple different predictors, represented in terms of odds ratios (OR).
- An OR >1 indicates increase in odds of the outcome and OR <1 indicates a decrease in odds of the outcome.
- For categorical predictors (e.g. age), the ORs represent the increase in odds of the outcome occurring, compared with the (arbitrarily) chosen reference group.
- For continuous predictors (e.g. age in years), the ORs would represent the increase in odds of the outcome occurring, for each unit increase in the predictor.

A case-control study used logistic regression to examine factors associated with maternal death due to direct pregnancy complications using 14 previously identified risk factors (Nair et al. *BJOG* 2015;122:653–62). In a univariable analysis, only one predictor is included in the model and the model shows the association between the single predictor and the outcome, without any consideration of other characteristics. In a multivariable analysis, more than one predictor is included in the model. Multivariable models depict the relationship between multiple characteristics and the outcome, allowing for the impact of other characteristics. This is sometimes referred to as an adjusted association. In Table 1, the adjusted odds ratios and corresponding 95% CI for each variable are provided for all 14 variables.

The adjusted odds ratio value gives the odds of maternal death compared with the reference group, with a 95% CI assessing the statistical significance of that variable. A confidence interval that includes the null value of 1 (i.e. the odds between the two groups are equal) indicates that the association is not statistically significant.

In the example (Table 1), age has been categorised with the reference group being women 'age 20–34 years'. For those aged <20 years the odds ratio is 0.76, which can be interpreted as a 24% reduction in odds of maternal death (after adjusting for other characteristics listed in Table 1) compared with those aged 20–34 years. The corresponding 95% CI (0.29–2.03) shows that the odds can range from a 71% reduction to a doubling in odds compared with those aged 20–34 years. This interval includes the null value of 1; therefore, the odds for maternal death for those aged <20 years are not statistically significant (at the 5% level) compared with those aged 20–34 years. Had age been treated as a

Table 1. Multiple logistic regression analysis displaying the adjusted odds ratios for the variables of interest with their corresponding 95% CI (an odds ratio of 1 indicates the reference group)

Risk factor	Adjusted odds ratio	95% CI
<b>Age (years)</b>		
<20	0.76	0.29–2.03
20–34	1	
≥35	0.94	0.60–1.48
<b>Parity</b>		
Nulliparous	1.05	0.62–1.78
1–3	1	
>3	0.79	0.43–1.43
<b>Body mass index (kg/m<sup>2</sup>)</b>		
<18.5	1.56	0.57–4.28
18.5–30	1	
≥30	1.05	0.66–1.70
Multiple pregnancy	0.67	0.22–2.01
Gestational diabetes	1.43	0.59–3.44
Hypertensive disorders of pregnancy	2.44	1.31–4.52
Anaemia	2.39	0.60–9.47
Inadequate use of antenatal care	15.9	6.73–37.4
Smoking status	0.79	0.45–1.39
Substance misuse	10.2	1.81–57.0
Previous pregnancy problems	2.21	1.34–3.62
Pre-existing medical problems	4.82	3.14–7.40
Employment status	1.27	0.65–2.47
<b>Ethnicity</b>		
White European	1	
Indian	2.70	1.14–6.43
Pakistani	2.10	0.86–5.11
Bangladeshi	1.21	0.27–5.45
Other Asian	1.08	0.36–3.27
Black Caribbean	0.93	0.24–3.64
Black African	1.09	0.51–2.31
Other/mixed	1.46	0.59–3.61

continuous variable, then the odds ratio would represent the increase in odds (of maternal death) for each unit (e.g. year) increase in age.

If there is an 'inadequate use of antenatal care' then there is an estimated 15.9 times increase in odds of maternal death compared with if an 'adequate use of antenatal care' was received. The 95% CI indicates that these odds might range from 6.73 to 37.4. Although this confidence interval seems relatively wide, because it does not include the null value of one, it is supportive of an increase in odds and rules out a decrease in odds.

Logistic regression models can be used to estimate odds of the event (e.g. maternal death) for individuals. Consider for example a mother aged  $\geq 35$  years with substance misuse and all other characteristics having the reference value (e.g. no multiple pregnancy and no gestational diabetes). To estimate the combined odds ratio, the individual odds ratios are simply multiplied together, producing an odds ratio of 9.55 ( $0.94 \times 10.2$ ). The 95% CI for this odds ratio cannot simply be multiplied together and as in the case of linear regression, statistical programmes are required for this calculation.

#### Useful resources

A comprehensive and detailed look into odds and odds ratios:

- <http://www.bmj.com/content/320/7247/1468.1>

An informative way of looking further into logistic regression:

- <http://www.bmj.com/content/347/bmj.f4488##>

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None declared by CE. KH receives fees as a statistical reviewer for BJOG outside of this work. Completed disclosure of interests form available to view online as supporting information.

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#### Data availability statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study. ■