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Public Health Wales Observatory

Research Evidence Review: Impact of Distance/Travel Time to Maternity Services on Birth Outcomes

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This document is available at www.publichealthwales.org/maternityreview

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1 Contents

2 Summary

This research evidence review considers the evidence for an association between the time or distance needed to travel to, and between, maternity services and adverse birth outcomes.

The method for this evidence review followed systematic review principles detailed in an *a priori* protocol for addressing a set of explicit questions; a full systematic review was not possible in the time available.

All studies included in this review are observational, and all but one of these, cross-sectional in design. Due to inconsistent findings, considerable heterogeneity[1] between studies and methodological weaknesses, it is not possible to draw clear conclusions about the association between travel time or distance between the mother's place of residence and maternity services and adverse outcomes. Also for reasons of heterogeneity, a meta-analysis would not have been appropriate.

Five studies were found that examined the impact of travel time on adverse birth outcomes. Two of the five considered travel time to the actual hospital of birth, the remaining studies used time to nearest available hospital or did not specify. The studies used a range of methods to assess travel time and used different time categories in their analysis. They considered a range of outcome measures including mortality, admission to neonatal intensive care, out of hospital delivery and meconium stained amniotic fluid. Mortality outcomes differed in definition between the studies.

Five studies were found that examined the impact of travel distance on adverse birth outcomes, one of these studies considered the distance from the mothers residence to the actual hospital of birth, rather than distance to nearest hospital. Measurement of distance varied across the studies, some used straight line distance and others distance by road. The studies differed in the distance categories they used in their analysis. Mortality outcomes differed in definition between the studies.

This research evidence review did not find conclusive evidence to support a causal link between increasing distance, or the time, required to travel from mother's residence to maternity services and adverse birth outcomes. All the studies finding any evidence of such an association were limited by their inability to account for important contributory factors and confounders (e.g. referral to specialist maternity units) and their reliance on a number of unsupported assumptions (e.g. women are at home at the onset of labour).

[1] This means the variability in the way in which the exposure (travel time, or distance) and the outcomes used in the studies were defined and measured.

All studies included in this review are observational in design and it is inappropriate to draw conclusions about the relationship between distance, or the time, required to travel from mother's residence to maternity services and adverse birth outcomes from any single observational study without considering the overall evidence base. Multiple good quality studies consistently demonstrating a strong statistical association between travel time or distance and adverse outcomes, after taking into account possible confounding and other factors which have an influence on the outcome, would be needed in order to draw conclusions about a probable cause-effect relationship.

The studies included in this review did not consistently demonstrate a strong statistical association between travel time or distance and adverse outcomes and were not considered of good quality because of their inability to sufficiently account for possible confounding and other factors likely to have an influence on the outcome.

Furthermore, adverse birth outcomes and appropriate location for delivery are subject to multiple influences, such as health, logistics and choice. None of the included studies provided a hypothesis, or used appropriate statistical methods, to distinguish between these interrelated issues. As a consequence none provide results that are able to answer the question of whether time or distance travelled to services has an independent impact on outcome.

3 Background and purpose

Work is being conducted in north Wales to develop and implement a service delivery model that will support safe, sustainable and efficient maternity, neonatal and paediatric services. This independent research evidence review is being undertaken to support the consultation on maternity services in north Wales. Specifically this research evidence review considers the evidence for an association between the time or distance needed to travel to, and between, maternity services and adverse birth outcomes.

4 Research evidence review questions

This research evidence review considered one primary and two secondary questions.

Primary question:

Is there an association between travel time, or distance to inpatient maternity services and birth outcome?

Secondary questions:

Is increasing travel time or distance from start of labour to inpatient maternity unit delivery associated with any adverse impact on birth outcome?

Is increasing travel time or distance between stand alone midwife led unit (MLU) or place of residence for planned home births and obstetric (consultant) led units associated with any adverse impact on birth outcome?

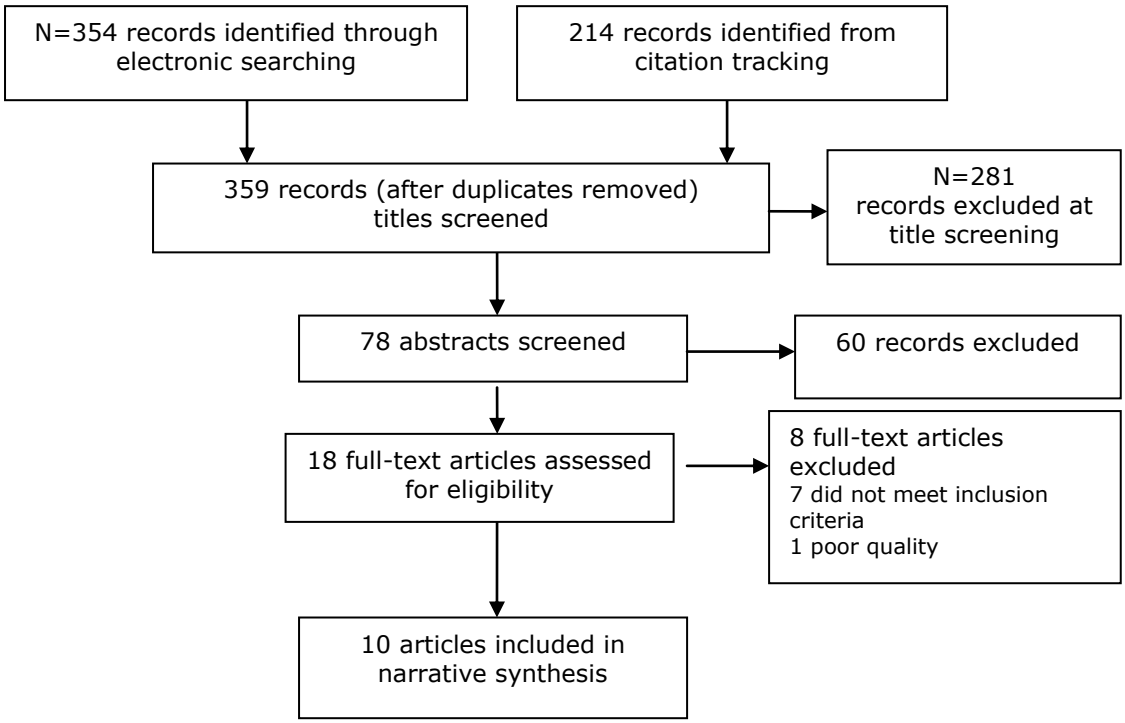
5 Review methods

The methods for this evidence review followed systematic review principles; a full systematic review was not possible in the time available. Systematic reviews aim to provide an objective, reliable synthesis of the evidence base through following an explicit methodology, set out *a priori* in a protocol, which is transparent, repeatable and which aims to minimise bias. In brief, a two-stage filtering process was used; firstly, evidence sources located by the systematic search strategy were filtered for relevance, based on their titles and in the second filtering stage, on details contained in abstracts. The full-text of sources which were retained following this filtering process were examined and critically appraised using standardised checklists. The applicability, quality and strength of the evidence was considered. Relevant data were then extracted from included sources into an Evidence Summary Table (Annex 1).

6 Research evidence review findings

6.1 PRISMA[2] diagram

Figure 1: Flow of information through the evidence review



6.2 Included studies

Characteristics of the included studies are set out in Table 1.

6.2.1 Design

All included studies were observational and all but one (a case-control study) were cross sectional in design. All studies used data from routine sources for example birth certificates, population based registers, specialist databases or medical records, and most conducted multivariate analysis to provide measures of the contribution of each variable to the outcome of interest. With the exception of the single case control study no primary data were collected for the purposes of the included studies.

[2] Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) http://www.prisma-statement.org/

6.2.2 Settings

The review protocol limited settings to pre 1974 OECD countries in order to increase the applicability to Wales[3]. Of the 10 included studies one was conducted in Wales, two in England, three in France, two in British Columbia, one each in Finland and the Netherlands.

6.2.3 Outcomes

Outcomes included in the protocol were perinatal mortality[4]; neo-natal mortality[5]; maternal mortality; accidental/unplanned out of hospital delivery; admission to neo-natal intensive care; meconium aspiration syndrome; Apgar<7 at 5 minutes; neo-natal encephalopathy, intra uterine death (stillbirth), brachial plexus injury.

Outcomes in the included studies were perinatal (including or excluding stillbirths) and neonatal mortality, unplanned out of hospital delivery, admission to neonatal intensive care, meconium aspiration and Apgar score at five minutes.

No studies were found that focused on transfers from stand alone midwifery led units, or home births, and any adverse outcomes.

6.3 The impact of travel time

Five studies were found that examined the impact of travel time on adverse birth outcomes. Of the five only two considered travel time to the actual hospital of birth; the remaining studies used time to nearest available hospital or did not specify. The studies were generally heterogeneous, preventing direct comparison. They used a range of methods to assess travel time and employed different time categories in their analyses. They also considered a variety of outcome measures including mortality, admission to neonatal intensive care, out of hospital delivery and meconium stained amniotic fluid. Mortality outcomes differed in definition between the studies.

A study conducted in Burgundy, France, looked at the travel time by road to the nearest maternity unit (Table 1) (Combier et al 2013). The maximum travel time was 72 minutes. This found no significant increase in odds ratio with increasing travel time, for stillbirth and perinatal mortality. A significant increase was found in the adjusted odds ratio (AOR) for meconium stained amniotic fluid with travel times of 30 minutes

[3] Pre 1974 OECD countries are; Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK and USA.

[4] Foetal deaths after 24 completed weeks of gestation and death before 7 completed days following live birth

[5] Death before the age of 28 completed days following live birth.

or more; the odds ratio increased with distance 31 to 45 minutes AOR 1.59, 95% CI 1.16 to 2.19 and for 46 minutes or more AOR 3.68 98% CI 2.50 to 5.40. A significant association was also found for out of hospital deliveries, and the odds ratio did not show any evidence of increasing with increasing time (16 to 30 minutes AOR 1.73 95% CI 1.23 to 2.46; 31 to 45 minutes AOR 1.64, 95% CI 1.06 to 2.54; no out of hospital deliveries were reported for travel times of 46 minutes or more) (Table 2). This study was unable to control for known maternal lifestyle risk factors or levels of maternal and neonatal care which may be associated with both increased time to services and poorer outcomes and therefore contribute to, or completely explain, the observed association (Table 1).

A study in Cumbria considered travel time to hospital from resident postcode at the time of birth (Table 1) (Dummer and Parker, 2004). In the analysis for the years 1950 to 1993 there was no significant association between travel time and early neonatal death, neonatal death or post neonatal death (Table 2). As infant mortality fell considerably over the study period the analysis was stratified into four time periods. In the analysis of the most recent period, which included the years 1980 to 1993, there remained no significant increase in the odds ratio for any of the categories of infant death. This study was unable to control for any impact that maternal lifestyle and neonatal risk factors or access/uptake of maternal and neonatal care may have had on this association (Table 1).

A study in British Columbia found a significant increase in the odds ratio for perinatal mortality (stillbirths and early neonatal mortality not further defined) where mothers lived more than four hours travel time away from any maternity services when compared to those living within an hour of obstetric maternity services with caesarean section capability (AOR 3.17 95% CI 1.45 to 6.95; Table 2) (Grzybowski, Stoll, Kornelsen 2011); No significant association was seen where mothers lived more than one but less than four hours away from maternity services. The study also considered the impact of travel time on unplanned out of hospital births. A significant association was seen but they found no increase in odds ratio with increasing travel time; women living 1 to 2 hours away from services (AOR 6.41 95% CI 3.69 to 11.28) and for women more than 4 hours away (AOR 3.63 95% CI 1.4 to 9.4) but no significant increase for women living 2 to 4 hours (AOR 0.92 95% CI 0.22 to 3.88). Hospital capacity or delayed departure from residence were not considered as a reason for out of hospital birth. Risk of admission to level II neonatal intensive care (NICU 2) was also considered (Table 2) and again a significant association was seen but no trend with increasing time; for the babies of women living 1 to 2 hours away AOR 2.20 (95% CI 1.59 to 3.05), a reduced odds for women living 2 to 4 hours away AOR 0.31 (95% CI 0.14 to 0.65) and a slightly, but not significantly, increased odds ratio for the babies of women living more than 4 hours away AOR 1.07 (95% CI 0.54 to 2.12). This study did not control for any effect of maternal lifestyle risk factors (Table 1). The study was also unable to account for women who temporarily

moved closer to medical facilities in preparation for the birth, either because of increased risk or distance, and were therefore not at their place of residence at the onset of labour.

One study conducted in Wales was identified (Table 1) (Paranjothy et al 2014). This found no significant increase in the odds ratio for every 15 minute increase in travel time to the nearest hospital (Table 2). For every 15 minute increase in travel time to actual hospital of birth the odds ratios for adverse outcomes increased slightly; this increase was statistically significant. The adjusted odds ratio for the association between increasing travel time (in 15 minute intervals) and death in the first 6 days of life was 1.13 (95% CI 1.07 to 1.20), for late neonatal death (death at 7 to 27 completed days of life) was 1.15 (95% CI 1.05 to 1.26) and, for intrapartum stillbirth and neonatal death combined was 1.15 (95% CI 1.09 to 1.20). The study was unable to adjust for maternal or foetal medical conditions and risk factors that may have necessitated the delivery taking place in a specialist facility; this may have increased death, adverse outcomes and the time travelled to actual hospital of birth. Additionally, the study was unable to consider whether capacity at the nearest hospital was a contributory factor for births not taking place at the nearest facility.

A Dutch study found a slight increase in the odds ratio for mortality (combined intrapartum, early or late neonatal mortality) associated with a travel time to hospital or outpatient clinic where the birth took place of 20 minutes or more compared with less than 20 minutes (AOR 1.17 95% CI 1.002 to 1.36) (Table 1 Ravelli et al 2010). There was a slight but significant increase in the AOR for adverse outcome (combined endpoint of mortality and/or 5 minute Apgar below 4, and/or transfer to NICU) and limited indication of a dose response relationship; for 15-19 minutes travel time AOR 1.11 (95% CI 1.02 to 1.21); for ≥ 20 minutes AOR 1.27 (95% CI 1.17 to 1.38). Additionally, when travel time was dichotomised into more or less than 20 minutes, there was an increase in the odds ratios for death within 24 hours of birth (AOR 1.15 95% CI 1.13 to 2.02) and death 0 to 7 days after birth (AOR 1.37 95% CI 1.12 to 1.67); death 8 to 27 days after birth was not significantly associated with time however (AOR 1.24 95% CI 0.67 to 2.27). The analysis was not adjusted for maternal or neonatal risk factors that may be associated with both increased risk of adverse outcomes and use of a more distant, specialist, hospital/ avoidance of local outpatient facilities (Table 1).

6.4 The impact of distance

Five studies were found that examined the impact of travel distance on adverse birth outcomes, one of these studies considered the distance from the mother's residence to the actual hospital of birth. Again, the studies were considerably heterogeneous in their methods. Measurement of

distance varied across the studies, some used straight line distance and others distance by road. The studies differed in the distance categories they used in their analysis. Mortality outcomes differed in definition between the studies.

A French study found that the odds of out of hospital birth increased with distance from the closest maternity unit (Blondel et al 2015); the study was unable to differentiate between planned and unplanned out of hospital births but indicated that planned home births were uncommon in France. They also did not clarify if the nearest hospital (for which the analysed distance was calculated) was the intended hospital of birth. There was an increase in odds ratio associated with all distances when compared with women living within 5 km of the nearest maternity unit (Table 3). At every distance category analysed, odds ratios were greater for women with a parity of 3+ in comparison to women with a parity of 1 or 2 (Table 3). There was a J shape relationship between social class and out of hospital birth[6]. The study was unable to adjust for maternal lifestyle factors or maternal and neonatal health/risk factors that may have influenced this association. Hospital capacity; planned delivery in a more distant hospital and delayed departure from residence were not considered as a reason for out of hospital birth.

A study conducted in British Columbia, looked at birth outcomes amongst women who were 35 or older (Lisonkova et al 2011 Table 1). Occurrence of stillbirth (defined as death in utero at 20 weeks gestation or later) was higher among mothers living 50-150km and >150 km versus those living <50km from the nearest hospital with caesarean section capability. However, no significant trend was found in the rate of stillbirth after adjustment for confounding. As distance to nearest hospital with caesarean section facilities increased, there was a significant increase in the odds ratio for perinatal death (AOR 1.53; 95% CI 1.10 to 2.12); no significant difference for rate of NICU admission by distance was found (Table 3). The study was also unable to capture the actual location of the mother at onset of labour so could not account for any planned moves closer to facilities, as can be the case in Canada due to large distances, and could not adjust for some risk factors related to maternal and neonatal health that may influence the association seen.

A case control study that took place in Finland looked at trends and reasons for out of hospital delivery in one university hospital catchment area (Ovaskainen et al 2015). This found that a distance to the delivery unit of at least 35km was associated with unplanned out of hospital

[6] The lowest rate was of out of hospital births was seen for the shop assistant and service workers group, towards the middle of the occupation based socio-economic categorisation.

delivery (AOR 5.02 (95% CI 1.80 to 14.04)[7]. The analysis was not adjusted for social risk factors and did not account for hospital capacity as a reason for out of hospital deliveries.

The authors of a study conducted in west Cumbria using the same database as the Dummer and Parker (2004) study, reported no significant increase in risk of stillbirth with distance from either the first or second nearest maternity services to mother's residence (Parker, Dickinson, Morton-Jones 2000). This analysis was only adjusted for year of birth, father's social class and birth order (Table 1).

A study in France found no significant increase in the relative risk of stillbirth (foetal death ≥22 weeks gestation or ≥ 500g) and neonatal death (all infant deaths before 28 days of life) associated with increasing distance to nearest maternity services (Pilkington et al 2014); relative risk for neonatal death was found to be significantly lower in mothers living 5-15km and 30-45km from the services compared to those living <5km away (RR 0.91 and 0.90 respectively; CI reportedly excluding 1). There was some increase in relative risk associated with neonatal death following out of hospital birth, but this showed no clear trend with increasing distance; for mothers living 15-30 km from services (RR 1.58) and greater than 45 km (RR 3.68), however no significant effect was seen for mothers living between 30 and45km from services (see Table 3). No confidence intervals were provided but the authors reported that they did not include 1[8]. No analysis of the association between out of hospital birth and distance was reported; an increase in the proportion of out of hospital births with increased distance would potentially confound the association seen between distance and neonatal death in those infants born out of hospital due to the denominator used. The analysis could not be adjusted for risk factors associated with maternal health and lifestyle, neonatal risk factors and maternal or neonatal care services.

[7] This study has been accepted for publication but was only available in unedited format at the time of writing. The results tables for the study were not available.

[8] The authors note that the confidence intervals exclude 1; this is an approximate method of assessing if the estimate is significantly different from the baseline category.

Table 1: Characteristics of included studies[9]

Reference	Country	Years of data	Study design	Study population size	Exposure	Outcomes	Level of consideration given to potential confounders and influential factors					Significant association reported
							Social factors	Maternal lifestyle	Maternal health	Neonatal health/risk factors	Maternal and neonatal care services	
Blondel et al 2011	France	2005-2006	Cross sectional	1,349,751	Distance, to nearest maternity unit.	Out of hospital birth (planned and unplanned)	Limited consideration	No consideration	Limited consideration	No consideration	No consideration	Yes
Combier E et al 2013	France, Burgundy	2000 to 2009 but births from 2002 and 2008 were excluded	Cross sectional	111,001	Travel time to nearest maternity unit.	Stillbirth; Extended perinatal mortality; Meconium stained amniotic fluid; Unplanned out of hospital deliveries	Limited consideration	No consideration	Some consideration	Limited consideration	No consideration	No for stillbirths and perinatal mortality Yes for unplanned out of hospital delivery Partially for meconium stained amniotic fluid
Dummer & Parker 2004	UK Cumbria	1950 to 1993	Cross sectional	292, 882	Travel time to hospitals (different hospitals used for different analyses)	Early neonatal death; Neonatal death; Post neonatal death	Limited consideration	No consideration	Limited consideration	No consideration	No consideration	No
Grzybowski, Stoll, Kornelsen 2011	Canada, British Columbia, rural catchments	April 1 2000 to March 31 2004	Cross sectional	49, 402	Distance to nearest maternity services with caesarean section capability	Perinatal mortality; Prematurity; Admissions to NICU; Unplanned out of hospital deliveries.	Limited consideration	Some consideration	Well considered	Limited consideration	No consideration	Partially for perinatal mortality Partially for NICU admission Partially for unplanned out of hospital delivery
Lisonkova et al 2011	Canada, British Columbia	April 1 1999 – March 31 2003	Cross sectional	29, 698	Distance to nearest hospital with caesarean section capacity	Stillbirth; Perinatal death; Preterm birth; NICU admission for more than 1 day	Some consideration	Well considered	Some consideration	Limited consideration	Some consideration	No for stillbirth No for NICU admission Yes for perinatal death

[9] Further detail on the included studies is included in Annex 1

Ovaskainen et al 2015[10]	Finland, catchment area of single university hospital	1996-2011	Case control	76,773	Travel distance to hospital of birth	Out of hospital births; 5 minute Apgar scores	Limited consideration	Limited consideration	Limited consideration	Some consideration	Some consideration	Partially for out of hospital delivery
Paranjothy S et al 2014	Wales	1995 to 2009	Cross sectional	412 827	Travel time to hospital of birth	Intrapartum stillbirth; Early neonatal death; Late neonatal death	Some consideration	No consideration	Some consideration	Limited consideration	No consideration	No for all outcomes using distance to nearest hospital. No for early neonatal death using actual hospital of birth Yes for intrapartum stillbirth and late neonatal death **using actual hospital of birth**
Parker Dickinson, Morton Jones 2000	UK west Cumbria	1 January 1950 to 30 September 1989	Cross sectional	79,229	Distance to nearest maternity units open at the time.	Stillbirth	Limited consideration	No consideration	Limited consideration	No consideration	No consideration	No
Pilkington H et al 2014	France	2002-2005 foetal deaths 2001-2008 for births	Cross sectional	112 988 births 2002 – 2005. 6 217 778 births 2001-2008	Distance to nearest maternity unit	Still births; Neonatal death	Some consideration	No consideration	No consideration	No consideration	No consideration	No for stillbirth. Partial for neonatal mortality
Ravelli et al 2010	Netherlands	2000 to 2006	Cross sectional	751 926	Travel time to hospital or outpatient clinic where birth took place	Intrapartum and neonatal mortality; Adverse neonatal outcomes (5 min Apgar <4, and/or transfer of newborn to NICU at birth)	Some consideration	No consideration	Limited consideration	Limited consideration	Some consideration	Yes for all mortality travel time ≥20 minutes Yes for adverse outcome travel time ≥15 minutes

[10] This was a pre-publication paper and the full results table were not available at the time of writing.

Table 2: Results - impact of travel time

Reference	Results
Combier et al 2013	**Stillbirths** Travel time minutes ≤15 Ref n=333 16-30 OR 1.16 (95% CI 0.96 to 1.40) n=148 31-45 OR 1.31 (95% CI 0.89 to 1.93) n=50 ≥ 46 OR 1.90 (95% CI 0.70 to 5.15) n=3 **Perinatal mortality** Travel time minutes ≤15 ref n=452 16-30 OR 1.08 (95% CI 0.9 to 1.29) n=195 31-45 OR 1.18 (95% CI 0.86 to 1.62) n=59 ≥ 46 OR 1.85 (95% CI 0.66 to 5.19) n=4 **Meconium stained amniotic fluid** Travel time minutes ≤15 ref n=5448 16-30 OR 1.13 (95% CI 0.91 to 1.41) n=2393 31-45 OR 1.59 (95% CI 1.16 to 2.19) n=676 ≥ 46 OR 3.68 (95% CI 2.50 to 5.40) n=38 **Out of hospital delivery** Travel time minutes ≤15 ref n=132 16-30 OR 1.73 (95% CI 1.23 to 2.46) n=93 31-45 OR 1.64 (95% CI 1.06 to 2.54) n=29 ≥ 46 no out of hospital birth recorded n=0
Dummer & Parker, 2004	**1950 to 93** Early neonatal death Travel time >17 to 35 minutes OR 0.97 (95% CI 0.89 to 1.06) n=789 Travel time >35 minutes OR 0.95 (0.81 to 1.10) n=196 Neonatal death Travel time >17 to 35 minutes OR 0.96 (95% CI 0.89 to 1.04) n= 946 Travel time >35 minutes OR 0.95 (95% CI 0.83 to 1.09) n=239 Post neonatal death Travel time >17 to 35 minutes OR 0.97 ((5% CI 0.86 to 1.09) n=400 Travel time >35 minutes OR 0.95 (0.77 to 1.17) n=98 **1980 to 93** Early neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI 0.79 to 1.29) n=98 Travel time >35 minutes OR 1.32 (95% CI 0.88 to 1.96) n=27 Neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI0.81 to 1.25) n=125 Travel time >35 minutes 1.30 (95% CI 0.91 to 1.87) n=34 Post neonatal death Travel time >17 to 35 minutes OR 1.14 (95% CI 0.88 to 1.47) n=9 Travel time >35 minutes OR 0.98 (95% CI 0.59 to 1.62) n=17 **1950 to 93** Early neonatal death Travel time >17 to 35 minutes OR 0.97 (95% CI 0.89 to 1.06) n=789 Travel time >35 minutes OR 0.95 (0.81 to 1.10) n=196 Neonatal death Travel time >17 to 35 minutes OR 0.96 (95% CI 0.89 to 1.04) n= 946 Travel time >35 minutes OR 0.95 (95% CI 0.83 to 1.09) n=239 Post neonatal death Travel time >17 to 35 minutes OR 0.97 ((5% CI 0.86 to 1.09) n=400 Travel time >35 minutes OR 0.95 (0.77 to 1.17) n=98 **1950 to 59** Early neonatal death

Reference	Results
	Travel time >17 to 35 minutes OR 0.96 (95% CI 0.84 to 1.10) n=305 Travel time >35 minutes OR 0.87 (95% CI 0.68 to 1.10) n=78 Neonatal death Travel time >17 to 35 minutes OR 0.94 (95% CI 0.83 to 1.07) n=364 Travel time >35 minutes OR 0.83 (95% CI 0.67 to 1.04) n=91 Post neonatal death Travel time >17 to 35 minutes OR 0.90 (95% CI 0.74 to 1.09) n=153 Travel time >35 minutes OR 0.66 (95% CI 0.46 to 0.96) n=32 **1960 to 69** Early neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI 0.87 to 1.18) n=241 Travel time >35 minutes OR 0.99 (95% CI 0.75 to 1.29) n=59 Neonatal death Travel time >17 to 35 minutes OR 0.98 (95% CI0.85 to 1.12) n=280 Travel time >35 minutes 1.01 (95% CI 0.79 to 1.29) n=73 Post neonatal death Travel time >17 to 35 minutes OR 0.89 (95% CI 0.69 to 1.14) n=88 Travel time >35 minutes OR 1.47 (95% CI 1.04 to 2.09) n=37 **1970 to 79** Early neonatal death Travel time >17 to 35 minutes OR 0.91 (95% CI 0.75 to 1.10) n=145 Travel time >35 minutes OR 0.87 (95% CI 0.60 to 1.25) n=32 Neonatal death Travel time >17 to 35 minutes OR 0.94 (95% CI 0.79 to 1.12) n=177 Travel time >35 minutes OR 0.94 (95% CI 0.68 to 1.30) n=41 Post neonatal death Travel time >17 to 35 minutes OR 0.92 (95% CI 0.70 to 1.22) n=67 Travel time >35 minutes OR 0.72 (95% CI 0.40 to 1.29) n= 12
Grzybowski , Stoll , Kornelsen 2011	**Perinatal mortality** 1 to 2 hrs from maternity services (1,359 births) OR 1.04 (95% CI 0.48 to 2.22) 2 to 4 hrs from maternity services (747 births) OR 0.92 (95% CI 0.33 to 2.53) >4hrs from maternity services (506 births) OR 3.17 (95% CI 1.45 to 6.95) **NICU 2 admissions**[11] 1 to 2 hrs from maternity services (1,359 births) OR 2.20 (95% CI 1.59 to 3.05) 2 to 4 hours from maternity services (747 births) OR 0.31 (95% CI 0.14 to 0.65) > 4 hours from maternity services (506 births) OR 1.07 (95% CI 0.54 to 2.12) **Out of hospital delivery** 1 to 2 hrs from maternity services (1,359 births) OR 6.41 (95% CI 3.69 to 11.3) 2 to 4 hours from maternity services (747 births) OR 0.92 (95% CI 0.22 to 3.88) > 4 hours from maternity services (506 births) OR 3.63 (95% CI 1.4 to 9.4)
Paranjothy et al 2014	**All births** (trend for time with each 15 minute increase) **To actual hospital of birth** Intrapartum stillbirth OR 1.13 (95% CI 0.98 to 1.30) n=135 Early neonatal death OR 1.13 (95% CI 1.07 to 1.20) n=609 Late neonatal death OR 1.15 (95% CI 1.05 to 1.26) n=251 Intrapartum still birth and neonatal death combined OR 1.15 (95% CI 1.09 to 1.20) n=995 **To nearest hospital** Intrapartum stillbirth OR 1.11 (95% CI 0.83 to 1.48) n=135 Early neonatal death OR 0.99 (95% CI 0.86 to 1.15) n=609 Late neonatal death OR 1.00 (95% CI 0.79 to 1.25) n= 251 Intrapartum still birth and neonatal death combined 1.01 (95% CI 0.90 to 1.13) n=995 **Term births** n=387 429

[11] The study authors do not define this but the text says that admission criteria for NICU 2 are less stringent than those for NICU 3

Reference	Results
	To actual hospital of birth Intrapartum stillbirth OR 1.36 (95% CI 1.17 to 1.59) n=85 Early neonatal death OR 0.97 (95% CI 0.80 to 1.17) n=177 Late neonatal death OR 1.34 (95% CI 1.13 to 1.59) n=77 Intrapartum still birth and neonatal death combined OR 1.19 (95% CI 1.06 to 1.32) n=339 **To nearest hospital** Intrapartum stillbirth OR 1.06 (95% CI 0.74 to 1.53) n=85 Early neonatal death OR 0.89 (95% CI 0.68 to 1.15) n=177 Late neonatal death OR 1.43 (95% CI 0.97 to 2.12) n=77 Intrapartum still birth and neonatal death combined OR 1.03 (95% CI 0.86 to 1.25) n=339 **Nulliparous women** n=185 419 **To actual hospital of birth** Intrapartum stillbirth OR 1.21 (95% CI 1.02 to 1.44) n=69 Early neonatal death OR 1.15 (95% CI 1.06 to 1.25) n=303 Late neonatal death OR 1.11 (95% CI 0.97 to 1.28) n=116 Intrapartum still birth and neonatal death combined OR 1.16 (95% CI 1.08 to 1.24) n=488 **To nearest hospital** Intrapartum stillbirth OR 1.00 (95% CI 0.66 to 1.45) n=69 Early neonatal death OR 1.00 (95% CI 0.82 to 1.22) n=303 Late neonatal death OR 0.98 (95% CI 0.71 to 1.36) n=116 Intrapartum still birth and neonatal death combined OR 0.99 (95% CI 0.85 to 1.17) n=448
Ravelli et al 2010	**Mortality** Travel time to hospital <15 minutes OR reference 15-19 minutes OR 0.94 (95% CI 0.79 to 1.12) ≥20 minutes OR 1.17 (95% CI 1.00 to 1.36) For death within 24 hours of birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.51 (95% CI 1.13 to 2.02) For death within 0-7 days after birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.37 (95% CI 1.12 to 1.67) For death 8 to 27 days after birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.24 (95% CI 0.67 to 2.27) There was a slight increase in **adverse outcome** (combined endpoint of mortality and/or 5 minute Apgar below 4, and/or transfer of newborn to neonatal intensive care unit at birth) adjusted as above Travel time to hospital < 15 minutes reference 15 -19 minutes OR 1.11 (95% CI 1.02 to 1.21) ≥20 minutes OR 1.27 (95% CI 1.17 to 1.38)

Table 3: Results – impact of distance

Reference	Results
Blondel et al 2011	Distance to closest maternity unit and AOR for out of hospital deliveries **For women with parity 1 or 2** <5km –reference (for both 1-2 and 3+ parity analysis) 5-14 km from unit OR 1.14 (95% CI 1.03 to 1.27) 15-29 km OR 1.39 (95% CI 1.24 to 1.57) 30-44 km OR 1.78 (95% CI 1.55 to 2.05) 45+ km OR 2.47 (95% CI 2.02 to 3.02) **For women with parity 3+** < 5km OR 1.73 (95% CI 1.57 to 1.90) 5-14 km OR 2.32 (95% CI 2.04 to 2.63) 15-29 km OR 3.25 (95% CI 2.84 to 3.71) 30-44 km OR 3.71 (95% CI 3.13 to 4.41) 45+ km OR 6.46 (95% CI 4.92 to 8.48)
Lisonkova et al 2011	Rates of **stillbirth** were higher among mothers living 50-150km and >150 km versus those living <50km from the hospital. No significant trend in the rate of still birth was observed after adjustment for confounding however. As distance increased risk of **perinatal death** increased even after adjustment for confounders (AOR 1.53; 95% CI 1.10 to 2.12): adjusted for parity, single parent status, low income neighbourhood, aboriginal status, smoking, alcohol, drug use during pregnancy, congenital anomalies, previous spontaneous abortions, induced abortions, male gender and suboptimal prenatal care. Distance to nearest hospital with caesarean section facilities <50km (n=27,836) perinatal death n=221 (0.8%) 50-150km (n=1,534) perinatal death n=19 (1.2%) >150km n=328 perinatal death n=8 (2.4%) Rate of **NICU admission** did not show a significant difference by distance.
Ovaskainen et al 2015	The following variables were associated with out of hospital delivery (no analysis for travel time to unit) **Distance to delivery unit at least 35 km OR 5.02 (95% CI 1.80-14.04)**. Smoking during pregnancy OR 6.54 (95% CI 1.33 to 32.22) Short duration of labour OR 18.79 (95% CI 5.96 to 59.29) Single-mother status) OR 13.01 (95% CI 3.37 to 50.23) Number of previous births OR 7.02 (95% CI 1.83 to 26.95) <13 prenatal visits OR 2.73 (95% CI 0.95 to 7.84)
Parker, Dickinson, Morton-Jones 2000	No significant increase in stillbirth risk was found with distance of mothers residence from the first or second nearest maternity services after adjusting for year of birth, fathers social class and birth order. The overall test of the distance effects showed no significant increase in risk with increasing distance from either the first or second nearest maternity services (p=0.5, 0.11 respectively)
Pilkington et al 2014	**Stillbirth** Distance to nearest maternity unit <5 km Reference 5-15 km RR 0.99 15-30 km RR 1.01 30-45km RR 1.00 45+ km RR 1.08 **Neonatal mortality** Distance to nearest maternity unit <5 km Reference 5-15 km RR 0.91* 15-30 km RR 0.94 30-45km RR 0.90* 45+ km RR 0.96 **Neonatal deaths after out-of-hospital birth** Distance to nearest maternity unit <5 km Reference 5-15 km RR 1.10 15-30 km RR 1.58* 30-45 km RR 1.51 45+ km 3.68* * authors note confidence interval does not include 1 Number of deaths after out of hospital birth was 282 (2001- 2008)

7 Discussion

7.1 Overview

Conclusions about cause-effect relationships cannot be drawn directly from single observational studies. However, if multiple good quality studies consistently demonstrate strong or no statistical associations between the factor and outcome, after appropriately taking into account possible confounding factors; this is usually considered to indicate the probability, or lack (respectively), of a cause-effect relationship when the directionality of the relationship is clear.

All studies included in this review are observational, and all but one of these cross-sectional in design. It is difficult to draw a clear picture of the impact of travel time or distance between the mother's place of residence and maternity services from these studies because of the limitations of the study design. A meta-analysis of the available data would be helpful but is not appropriate because of the considerable heterogeneity between the included studies. This heterogeneity is because the studies have measured different exposures (travel time or distance to actual place of birth or to nearest maternity services) in different ways (see Annexe 1). For distance some are measures from the mothers' actual residence others from a geographical point for the same postcode or municipality. For travel time some measures are an estimation of likely time using emergency vehicles, others are straight line distances and for some there is not this level of detail. Outcomes, in particular the definitions for stillbirth and mortality, also differed.

A few of the included studies appear to provide evidence of an association between either time or distance to maternity service and adverse outcomes; however these studies were unable to adequately account for other potential causes of the observed association, confounders, such as referrals to more specialist maternity units due to maternal or neonatal risk factors. Additionally, the influences on adverse outcomes are multiple and many studies were unable to account for factors, such as maternal health, smoking and substance use, which are likely to have a considerable impact on the outcome.

None of the included studies appeared to have had an *a priori* hypothesis about how distance to services is likely to influence outcome. For example, is it the relationship between the distance to services and antenatal care, the distance that all women in labour need to travel to maternity services or the distance that women experiencing problems during labour need to travel to specialist services, care at delivery or post natal care that is postulated to have an impact on the outcome? None of the included studies provide a hypothesis, or had data available, that allowed them to distinguish between these inter-related issues and consequently none of

the studies provide results that are able to answer the more focused review questions.

The included studies do not appear to have set out in advance a justified threshold, or categorisation, of distance/time over which an effect might be anticipated. Differing time/distance categories and lack of explanation for why these have been chosen may indicate that the boundaries were set post hoc, potentially resulting in bias in how categorisation was made (e.g. choosing those categories that demonstrate more 'interesting' findings). With large datasets and multiple statistical testing it is also possible that statistically significant findings may have been the result of statistical error.

The included studies are subject to a number of additional limitations. Many were not able to (due to lack of data available to them) control for important confounders, for example access to antenatal care which may be associated with both adverse outcomes and distance/time to maternity services. It is of particular importance that recognised maternal or neonatal medical conditions and risk factors have not been controlled for in the majority of studies; prior knowledge of these conditions is likely to impact on individual delivery plans, the planned location of the birth, location of mothers anticipating the onset of labour and the stage of labour at which mothers attend, or are advised to attend, services; these factors are likely to confound a relationship between distance and the outcomes examined here to some degree. This remains the case for studies that were able to look at actual hospital of birth as well as those using the nearest facility.

Adverse outcomes are rare, which has resulted in the numbers in the included studies often being very small even when the studies include a large number of births; this may have affected the ability of the studies to detect any positive associations and power calculations[12] were not provided to allow this to be ruled out. Most of the included studies relied on existing data sources and there is some lack of information on the completeness and accuracy of these. Not all studies discuss this or address how they dealt with missing data (Annex 1). Maternity services were not well described in some of the included studies. Some specified the type of service, for example if they had NICU or caesarean section capacity, but many did not. Type of service may also have a significant impact on outcomes.

Taken together this means that the included studies are subject to a range of important limitations. Overall the level of confidence in the study findings is low for this reason.

[12] A power calculation can be used to calculate the minimum effect size that is likely to be detected in a study given the sample size of that study

7.2 Impact of travel time

The studies on the impact of time (Combier et al 2013; Dummer and Parker 2004: Grzybowski, Stoll and Kornelsen 2011; Paranjothy et al 2014 and Ravelli et al 2010) present an inconsistent picture. Of these only two (Paranjothy et al 2014; Ravelli et al 2010) considered the travel time to the actual facility where delivery took place. Both of these studies found some increase in risk of mortality with increasing time; however neither study was able to control for maternal risk factors which might have had a considerable impact on adverse outcomes (discussed below). The remaining studies looked at time to the nearest facility, which may or may not have been the facility where the birth took place, and found mixed results. Using nearest maternity facilities may appear to provide relevant information in terms of service planning, the studies were not able to take into account the complex nature of birth planning and risk management, maternal choice and hospital "catchment areas". Additionally, these studies have been unable to estimate what proportion of the births assumed to take place in the nearest facility that actually took place elsewhere.

The study conducted in Wales looked at actual hospital of birth and found that the odds ratio was slightly but significantly increased for every 15 minute increase in travel times for neonatal death up to the first 27 days of life (Paranjothy et al 2014). When distance to the hospital nearest the woman's residence was considered there was no significant increase. This suggests that the association is not geographical and is likely to be because the most vulnerable babies are transferred to the nearest tertiary centre, increasing the travel time.

This may also be an issue in the study by Ravelli et al. This Dutch study found a slight increase in mortality, and with a combined endpoint for adverse outcome, associated with a travel time of 20 minutes or more to the hospital or outpatient clinic where the birth took place (Ravelli et al 2010). The type of services provided by maternity facilities was not defined but the study states that deliveries took place in both hospital and outpatient clinics (Annex 1). The increase in the odds ratio for travel times of 20 minutes might be associated with higher risk pregnancies being transferred to hospital (rather than outpatient clinics) but the study did not differentiate these.

The study conducted in British Columbia (Grzybowski, Stoll, Kornelsen 2011) found an increase in perinatal mortality but only for a travel time greater than four hours. This study was also unable to adjust the analysis for maternal risk factors that were likely to have an impact on outcome.

7.3 Impact of distance

The studies on the impact of distance also present a inconsistent picture. Only one study considered the actual distance to the facility where birth took place but did not appear to account for factors such as referral specialist units (Ovaskainen et al 2015). This found that a distance to the delivery unit of at least 35km was associated with unplanned out of hospital delivery (AOR 5.02 (95% CI 1.80 to 14.04)). None of the other studies considered the actual distance to the facility where delivery took place which, as described above, ignores a number of important real world factors making it difficult to draw clear conclusions. One study from British Columbia found an increased risk of mortality (Lisonkova et al 2011); however this study only included women aged over 35 years. The study from France showed inconsistent changes in the odds ratio for neonatal mortality and neonatal mortality and out of hospital birth; the odds ratio did not increase consistently with distance (Pilkington et al 2014).

None of the studies identified by this evidence review provided sufficient detail on the type of maternity services to be able to identify those which were consultant or stand alone midwife led.

7.4 Applicability of evidence to Wales

Paranjothy et al (2014) was the most rigorous study identified. This employed robust exposure and outcome measures, examining time to actual hospital of birth in a large population cohort and accounting for a large number of known confounders using sound analytical methods. This study is also the most applicable having been conducted using recent data, including all births across Wales between 1995 and 2009.

Other included studies were conducted in countries likely to have economies similar to that of the UK but because of differences in the funding and delivery of healthcare, including maternity services, the studies in the UK are most likely to apply to Wales. Only two additional studies included were conducted in the UK (Dummer, Parker 2004; Parker, Dickinson Morton-Jones 2000). One study, conducted in Cumbria (Dummer and Parker 2004), included data from 1950 to 1993 and its findings may not apply to 2015 because of the fall in neonatal mortality rates over this period (the rate in 1993 was 4.2 and in 2013 was 2.7 (ONS, 2013)) and general changes in maternity care services. The study was also limited to one county. The second Cumbria study was limited to births in the west of the county and included data from 1950 to 1989 (Parker, Dickinson, Morton-Jones 2000); again these findings may not apply to Wales in 2015 due to the age of the data.

The remaining studies were conducted in countries where both the health care systems, delivery of maternity care and physical geographies may affect their applicability to Wales. Several studies, such as those carried

out in British Columbia, look at populations where a proportion of the population live over four hours away from their nearest maternity services, through potentially inaccessible terrain (Grzybowski, Stoll, Kornelsen 2011).

7.5 Limitations of the research evidence review

This review is based on systematic review principles and included a systematic literature search. Both the review and search aimed to be comprehensive and unbiased. It is possible however, that some relevant studies were not identified. Only studies published in English were included but these are the most likely to be applicable to Wales. Publication bias was considered but judged not to be a major concern because the full range of outcomes, from no impact of time or distance to significant impact of time or distance, are equally likely to be of interest and therefore studies with either findings are equally likely to be published. This is demonstrated by the range of studies included here.

8 Conclusions

This research evidence review did not find conclusive evidence to support a causal link between increasing distance, or the time, required to travel from mothers' residence to maternity services and adverse birth outcomes. Any study finding of such an association was compromised by the inability to account for other important contributory factors and confounders.

All studies included in this review are observational in design and it is inappropriate to draw conclusions about the relationship between distance, or the time, required to travel from mother's residence to maternity services and adverse birth outcomes from any single observational study without considering the overall evidence base. Multiple good quality studies consistently demonstrating a strong statistical association between travel time or distance and adverse outcomes, after taking into account possible confounding and other factors which have an influence on the outcome, would be needed in order to draw conclusions about a probable cause-effect relationship.

The studies included in this review did not consistently demonstrate a strong statistical association between travel time or distance and adverse outcomes and were not considered of good quality because of their inability to sufficiently account for possible confounding and other factors likely to have an influence on the outcome.

Furthermore, adverse birth outcomes and appropriate location for delivery are subject to multiple influences, such as health, logistics and choice.

None of the included studies provided a hypothesis, or used appropriate statistical methods, to distinguish between these interrelated issues. As a consequence none provide results that are able to answer the question of whether time or distance travelled to services has an independent impact on outcome.

It might be possible to answer the question of whether time or distance travelled has an impact on birth outcomes but this would require a different study design, such as a prospective cohort study, with data specifically collected that addresses not only a very specific question but also allows appropriate control for confounding and other factors such as distance/access to antenatal care, planned place of delivery and referrals to specialist maternity units.

9 References

Blondel B et al. 2011. Out of hospital births and the supply of Maternity units in France. *Health & Place*;17: 1170-73.

Combier E et al. 2013. Perinatal health inequalities and accessibility of maternity services in a rural French region: Closing maternity units in Burgundy. *Health & Place*; 24: 225-33.

Dummer TJB, Parker L. 2004. Hospital accessibility and infant death risk. *Arch Dis Child*; 89:232-4.

Grzybowski S, Stoll K, Kornelsen J. 2011. Distance matters: a population based study examining access to maternity services for rural women *BMC Health Services Research*; 11:147.

Lisonkova S et al. 2011 Birth outcomes among older mothers in rural versus urban areas: A residence based approach. *Journal of Rural Health*; 27 (2):211-19.

Office for National Statistics. 2013. *Childhood, Infant and Perinatal Mortality in England and Wales*. ONS statistical bulletin.. http://www.ons.gov.uk/ons/dcp171778_397789.pdf [Accessed 19 August 2015]

Ovaskainen K et al. 2015. Out-of-hospital deliveries have risen involving greater neonatal morality. *Acta Paediatrica* doi: 10.1111/apa.1311

Parker L, Dickinson H, Morton-Jones T. 2000. Proximity to maternity services and still birth risk. *Arch Dis Child Fetal Neonatal Ed*; 82: F167-F168

Paranjothy S et al. 2014. Perinatal outcomes and travel time from home to hospital. Welsh data from 1995 to 2009. *Acta Paediatrica*; 103: e522-27.

Pilkington H et al. 2014. Where does distance matter? Distance to the closest maternity unit and risk of foetal and neonatal morality in France. *European Journal of Public Health*; 24(6); 904-9

Ravelli ACJ et al. 2010. Travel time from home to hospital and adverse perinatal outcomes in women at term in the Netherlands. *BJOG*;118(4):457-65.

Annex I Evidence summary table

Study details	Overview	Author's conclusions & comments
Cross sectional – France – Out of hospital births		
Blondel B et al. 2011. **Out of hospital births and the supply of Maternity units in France** *Health & Place*;17: 1170-73 **Study type:** Cross sectional **Study Population:** 1,349,751 births in metropolitan[13] France (89.9% of all metropolitan births) **Outcomes:** Out of hospital birth **Duration:** 2005 to 2006	**Study summary:** Aimed to calculate **incidence of out of hospital births** and whether this varied **in relation to distance to closest maternity unit**. Also to assess if socio-demographic factors were related to distance and greater risk of out of hospital delivery. Distance calculated from centre of municipality where mother resided to centre of municipality where the nearest maternity hospital was located **Quality of study:** The study has a range of limitations, some of which were highlighted by the authors – see comments section. A major problem was the inability to distinguish between unplanned out of hospital births and planned home deliveries. The study authors do not address this issue and do not supply any data on the proportion of planned home deliveries in France. Limited data on potential confounders, no data on length of gestation or birthweight, maternal medical problems, maternal smoking. They also do not indicate if nearest maternity unit was the unit where birth took place. Type of services provided by the maternity units in the study was not defined. The study does not state if the distance categories used in the analysis were identified *a priori.* There is no rationale provided for these. **Findings:** 5740 women delivered out of hospital. There was a J shape relationship between social class and out of hospital birth. Adjusted odds ratios for out of hospital birth (compared with women parity 1 or 2 < 5km from maternity unit, adjusted for maternal age, occupation category, parity, distance from maternity unit, unit closure within 15km radius and rurality, increased with distance to closest maternity unit For women with parity 1 or 2 <5km –reference (for both 1-2 and 3+ parity analysis) 5-14 km from unit OR 1.14 95% CI 1.03 to 1.27 15-29 km OR 1.39 95% CI 1.24 to 1.57 30-44 km OR 1.78 95% CI 1.55 to 2.05 45+ km OR 2.47 95% CI 2.02 to 3.02 For women with parity 3+ < 5km OR 1.73 95% CI 1.57 to 1.90 5-14 km OR 2.32 95% CI 2.04 to 2.63 15-29 km OR 3.25 95% CI 2.84 to 3.71 30-44 km OR 3.71 95% CI 3.13 to 4.41 45+ km OR 6.46 95% CI 4.92 to 8.48	**Author's conclusions:** Out of hospital births are rare in France; however in underserved areas rates are higher, especially for women with higher parity. It is important to inform women, especially multiparas living far from their maternity unit about the risks associated with accidental births out of hospital. Particular attention should be given to the organisation of health services in remote areas where women have to travel a long distance for child birth in order to guarantee a minimum level of safety in emergency situations. **Comment:** The authors noted the following limitations; 11% of births were excluded to ensure good quality data – a sensitivity analysis was conducted to test the impact of this. Data available for analysis was limited because birth certificates were used. Distance was calculated from centre of each municipality and not from each mothers home. The study design means that a causal link between distance to maternity services and out of hospital births cannot be established. Findings may not generalise to Wales. Differences in the structure and funding of healthcare.

[13] Includes mainland France and French Islands in La Manche, Atlantic Ocean and Mediterranean Sea.

Study details	Overview	Author's conclusions & comments
Cross sectional – France – infant mortality, foetal distress and out of hospital births		
Combier E et al. 2013. **Perinatal health inequalities and accessibility of maternity services in a rural French region: Closing maternity units in Burgundy.** *Health & Place*; 24; 225-33 **Study type:** Cross sectional **Study Population:** All singleton births at or after 22 weeks of gestation at maternity units in Burgundy (France). Total 111, 001 deliveries. **Outcomes:** In utero foetal mortality (still births) and extended perinatal mortality (deaths in utero or in the first 28 days of life), foetal heart rate abnormalities and meconium stained amniotic fluid, unplanned out of hospital deliveries **Duration:** 2000 to 2009 but births in 2002 and 2008 excluded because of closure of units occurring in these years which may have caused specific problems for women delivering in those years which were not associated with distance to services.	**Study summary:** Analysed **effect of travel time to the closest maternity unit on pregnancy outcome** and prenatal management in Burgundy. Data from Burgundy perinatal database based on hospital discharge summary. Also linked to hospital admissions data and maternity units provided information on gestational age at birth and some socioeconomic risk factors. Travel time by road calculated from the town hall of the municipality of mother's residence to the town hall of the municipality with the nearest maternity unit. Travel times also recalculated using Google maps and exact addresses of maternity units – this did not change the distance classifications used. Maximum travel time was 72 minutes. **Quality of study:** No information on accuracy and completeness of data. No information on some potential confounders e.g. maternal smoking, maternal or neonatal medical conditions/risks. Not known if births took place in nearest maternity unit or where the mother was residing at onset of labour. Type of services provided by the maternity units in the study was not defined. Not stated if distance categories used in the analysis were identified a *priori,* no rationale provided for these. **Findings:** After adjusting for maternal age, sex of infant, gestation, history of pre-term delivery, obstetric history (individual level) and deprivation and level of urbanisation (aggregate level) travel times greater than 30 minutes were associated with an increased risk of meconium stained amniotic fluid and travel times greater than 15 minutes with an increased risk of out of hospital delivery Odds ratios adjusted as above **Stillbirths** Travel time minutes ≤15 Ref n=333 16-30 OR 1.16 (95% CI 0.96 to 1.40) n=148 31-45 OR 1.31 (95% CI 0.89 to 1.93) n=50 ≥46 OR 1.90 (95% CI 0.70 to 5.15) n=3 **Perinatal mortality** Travel time minutes ≤15 ref n=452 16-30 OR 1.08 (95% CI 0.9 to 1.29) n=195 31-45 OR 1.18 (95% CI 0.86 to 1.62) n=59 ≥46 OR 1.85 (95% CI 0.66 to 5.19) n=4 **Meconium stained amniotic fluid** Travel time minutes ≤15 ref n=5448 16-30 OR 1.13 (95% CI 0.91 to 1.41) n=2393	**Author's conclusions:** Our results show that in the region of Burgundy longer travel time to the nearest maternity unit had a negative effect on perinatal health outcomes. This type of study should be extended to other geographic regions of the same type, because if these results are generalisable, they should be considered in the assessments of the benefits, both medical and economic, expected from hospital restructuring especially in rural regions. **Comment:** The study authors noted the following limitations; all women living in the same geographic code were assigned the same travel time to maternity services, travel times were calculated simulating rapid ambulance type vehicles and may be an underestimate. Study design means that a causal link between distance to maternity services and the outcomes of interest cannot be established. Findings may not generalise to Welsh setting. This study was conducted in a single region in France. There are also differences in the model of healthcare delivery between France and UK.

Study details	Overview	Author's conclusions & comments
	31-45 OR 1.59 (95% CI 1.16 to 2.19) n=676 ≥46 OR 3.68 (95% CI 2.50 to 5.40) n=38 **Out of hospital delivery** Travel time minutes ≤15 ref n=132 16-30 OR 1.73 (95% CI 1.23 to 2.46) n=93 31-45 OR 1.64 (95% CI 1.06 to 2.54) n=29 ≥ 46 no out of hospital birth recorded n=0	

Study details	Overview	Author's conclusions & comments
Cross sectional – UK Cumbria – infant mortality and adverse outcome		
Dummer TJB, Parker L.2004. **Hospital accessibility and infant death risk.** *Arch Dis Child*;89:232-4 **Study type:** Cross sectional **Study Population:** Cumbria – all births in time period. 283 668 live births, 4325 stillbirths, 4889 infant deaths. **Outcomes :** Early neonatal death, neonatal death and post neonatal death (not further defined) **Duration:** 1950 to 1993	**Study summary:** Aimed to investigate whether **geographical accessibility to hospitals affected the risk of infant mortality** in Cumbria. Data was obtained from the Cumbrian Births Database. Travel time to hospital, in relation to hospitals open in the year of birth, were derived for all live and still births. Logistic regression used to investigate risk of infant mortality (early neonatal, neonatal and post neonatal deaths and still birth not further defined). Because infant mortality fell over the 43 year study period the analysis was stratified into four time periods. **Quality of study:** Unknown accuracy and data completeness. No information on some potential confounders for e.g. maternal smoking, BMI, education level, medical problems. Analysis is for travel time to hospital, do not know if this is hospital where birth took place. Infant death analysis included general hospitals and those with paediatric facilities. For stillbirths hospitals with maternity facilities were included. Type of services provided by maternity facilities not defined. Hospital accessibility defined by a function of travel time to hospital as a linear function in minutes, categorical function grouping travel time to close, medium, far – assumption is that this was set out *a priori* but not stated **Findings:** Risk of death did not increase with increasing travel time to hospital, either overall or within time periods. Analysis adjusted for year of birth, social class, birth order, multiple births. (Only overall and most recent time period included here)(maximum travel time was 70 minutes) Reference category 1 0-17 minutes travel time **1950 to 93** Early neonatal death Travel time >17 to 35 minutes OR 0.97 (95% CI 0.89 to 1.06) n=789 Travel time >35 minutes OR 0.95 (0.81 to 1.10) n=196 Neonatal death Travel time >17 to 35 minutes OR 0.96 (95% CI 0.89 to 1.04) n= 946 Travel time >35 minutes OR 0.95 (95% CI 0.83 to 1.09) n=239 Post neonatal death Travel time >17 to 35 minutes OR 0.97 ((5% CI 0.86 to 1.09) n=400 Travel time >35 minutes OR 0.95 (0.77 to 1.17) n=98 **1950 to 59** Early neonatal death Travel time >17 to 35 minutes OR 0.96 (95% CI 0.84 to 1.10) n=305 Travel time >35 minutes OR 0.87 (95% CI 0.68 to 1.10) n=78 Neonatal death	**Author's conclusions:** There was no evidence to suggest that living further from hospitals in terms of road travel time increased the likelihood of infant death or stillbirth in Cumbria. A limitation of this study was lack of data after 1993, which are more relevant to hospital location planning. Therefore, although we found no variation in infant death or stillbirth with increasing travel time to hospital, this evidence cannot be used to justify further centralisation of hospital services. However the data may be useful to support siting of future paediatric hospital facilities. **Comment:** Study design limits establishing a causal link between travel time to hospital and birth outcomes. Changes in the neonatal mortality rate may limit generalisation to 2015. Small numbers of deaths in category for longest travel time 1980 to 1993

Study details	Overview	Author's conclusions & comments
	Travel time >17 to 35 minutes OR 0.94 (95% CI 0.83 to 1.07) n=364 Travel time >35 minutes OR 0.83 (95% CI 0.67 to 1.04) n=91 Post neonatal death Travel time >17 to 35 minutes OR 0.90 (95% CI 0.74 to 1.09) n=153 Travel time >35 minutes OR 0.66 (95% CI 0.46 to 0.96) n=32 **1960 to 69** Early neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI 0.87 to 1.18) n=241 Travel time >35 minutes OR 0.99 (95% CI 0.75 to 1.29) n=59 Neonatal death Travel time >17 to 35 minutes OR 0.98 (95% CI0.85 to 1.12) n=280 Travel time >35 minutes 1.01 (95% CI 0.79 to 1.29) n=73 Post neonatal death Travel time >17 to 35 minutes OR 0.89 (95% CI 0.69 to 1.14) n=88 Travel time >35 minutes OR 1.47 (95% CI 1.04 to 2.09) n=37 **1970 to 79** Early neonatal death Travel time >17 to 35 minutes OR 0.91 (95% CI 0.75 to 1.10) n=145 Travel time >35 minutes OR 0.87 (95% CI 0.60 to 1.25) n=32 Neonatal death Travel time >17 to 35 minutes OR 0.94 (95% CI 0.79 to 1.12) n=177 Travel time >35 minutes OR 0.94 (95% CI 0.68 to 1.30) n=41 Post neonatal death Travel time >17 to 35 minutes OR 0.92 (95% CI 0.70 to 1.22) n=67 Travel time >35 minutes OR 0.72 (95% CI 0.40 to 1.29) n= 12 **1980 to 93** Early neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI 0.79 to 1.29) n=98 Travel time >35 minutes OR 1.32 (95% CI 0.88 to 1.96) n=27 Neonatal death Travel time >17 to 35 minutes OR 1.01 (95% CI0.81 to 1.25) n=125 Travel time >35 minutes 1.30 (95% CI 0.91 to 1.87) n=34 Post neonatal death Travel time >17 to 35 minutes OR 1.14 (95% CI 0.88 to 1.47) n=9 Travel time >35 minutes OR 0.98 (95% CI 0.59 to 1.62) n=17	

Study details	Overview	Author's conclusions & comments
Cross sectional – British Columbia – perinatal morality, unplanned out of hospital delivery, NICU admission		
Grzybowski S, Stoll K, Kornelsen J.2011. **Distance matters: a population based study examining access to maternity services for rural women** *BMC Health Services Research*; 11:147 **Study type:** Cross sectional **Study Population:** British Columbia (BC) 49,402 singleton births delivered beyond 20 weeks to women in rural catchments **Outcomes:** Newborn outcomes; perinatal mortality (including stillbirths and early neonatal mortality, prematurity (gestational age <37 weeks) admissions to NICU. Maternal outcomes induction, I^0 c section, unplanned out of hospital deliveries. **Duration:** April 1 2000 to March 31 2004	**Study summary:** Study aimed to document newborn and maternal outcomes as they related to **distance travelled to access the nearest maternity services** with caesarean section capability. Data was obtained from the BC Perinatal Health Program to define the location of all rural maternity services; GIS was used to create geographic catchments based on proximity to a maternity service level within 60 minutes of surface travel time. This definition was extended to women residing 1 to 2, 2 to 4 and greater than four hours travel time from the nearest maternity service with caesarean level capability. **Quality of study:** No detail on data source, and completeness and accuracy of data. There is no explanation for the exclusion of the births occurring in the urban and suburban areas. Cannot be sure how accurately residents postal code reflected the actual time they would need to travel to services – rural area with sparse population distance was defined using postal code centroids – do not know size of area one postcode covered. Assumption that travel distance categories were set *a priori* but not specified, no rationale for these. **Findings:** Hierarchical logistic regression analyses to examine the effect of obstetric service level on newborn and maternal outcomes was conducted. This controlled for maternal age and parity and risk factors and ecological determinants of outcomes (catchment level social vulnerability and proportion of Aboriginal people residing within the catchment). Also controlled for pre-existing and pregnancy induced medical conditions. This found: **Perinatal mortality**1 to 2 hrs from maternity services (1,359 births) OR 1.04 (95% CI 0.48 to 2.22) 2 to 4 hrs from maternity services(747 births) OR 0.92 (95% CI 0.33 to 2.53) >4hrs from maternity services (506 births) **OR 3.17 (95% CI 1.45 to 6.95)** **NICU 2 admissions**[14] 1 to 2 hrs from maternity services(1,359 births) **OR 2.20 (95% CI 1.59 to 3.05)** 2 to 4 hours from maternity services(747 births) **OR 0.31 (95% CI 0.14 to 0.65)** > 4 hours from maternity services (506 births) OR 1.07 (95% CI 0.54 to 2.12) **Out of hospital delivery** 1 to 2 hrs from maternity services(1,359 births) **OR 6.41 (95% CI 3.69 to 11.3)** 2 to 4 hours from maternity services(747 births) OR 0.92 (95% CI 0.22 to 3.88) > 4 hours from maternity services (506 births) **OR 3.63 (95% CI 1.4 to 9.4)**	**Author's conclusions:** Distance matters; rural parturient women who have to travel to access maternity services have increased rates of adverse outcomes and newborns have increased numbers of NICU 2 and 3 care days. Rural parturient women are also subject to increased rates of inductions for logistical reasons and unplanned out of hospital deliveries. Health planners and policy makers need to consider such finding when planning the fate of rural services **Comment:** Study excluded 2,700 births to women in urban and suburban areas in the study period. Recognised congenital anomalies and late terminations were excluded from the analysis. The authors noted the following limitations the necessity of using a partial ecological design in order to include Aboriginal ethnicity and socio-economic status. Clinical criteria for admission to NICU were subject to variation according to provider Study design means that a causal link between time to travel to maternity services or type of maternity services and outcome cannot be established. May not generalise to the Wales setting. The health system in Canada has some similarities – it provides universal medical coverage for core health (but not a universal provider) but access costs for residents in remote and rural areas are usually the individuals responsibility. The population density in BC is much lower than Wales according to authors 4.7 per square km vs 149.1 in Wales (StatsWales midpoint 2014). Difference in the populations (some of the BC population described as Aboriginal) may not be comparable with Welsh population.

[14] The study authors do not define this but the text says that admission criteria for NICU 2 are less stringent than those for NICU 3

Study details	Overview	Author's conclusions & comments
Cross sectional – British Columbia – mortality and NICU admission		
Lisonkova S et al.2011. **Birth outcomes among older mothers in rural versus urban areas: A residence based approach.** *Journal of Rural Health*; 27:211-19 **Study type:** Cross sectional **Study Population:** All singleton births to 35+ women in British Columbia (BC) 29, 698 women **Outcomes:** Stillbirth (death in utero at 20 weeks gestation or later); perinatal death (stillbirth or death within the first 28 days after birth); preterm birth (<37 weeks), NICU admission for more than 1 day (NICU providing high dependency neonatal care such as infusion, total parenteral nutrition or mechanical ventilation) **Duration:** April 1 1999 to March 31 2003	**Study summary:** Aimed to examine **association between rural residence and birth outcomes in older mothers**, the effect of parity on this association and the trend in adverse birth outcomes in relation to the distance to the nearest hospital with caesarean section capacity. Distance to nearest hospital <50km, 50-150km and >150km calculated using GIS mapped shortest straight line between post code of mothers residence and hospitals. Post codes localised by central points – where applicable distances were recalculated to represent longer actual road distances. **Quality of study:** See comments for authors limitations. Using registry data (BC Perinatal Health Programme) and records linkage for vital statistics including neonatal deaths. No information of completeness and accuracy of data (or linkage). Distance rather than travel time used and no further explanation of when actual road distances were applied. No information on some potential confounders i.e. maternal and neonatal health. The study was unable to capture actual location of the mother at onset of labour and therefore account for any planned moves closer to facilities. Do not know if travel distance categories were set *a priori*, no rationale for these. **Findings:** Multivariate analysis using logistic regression was used to further evaluate associations for significant differences found using univariate analysis. Step backwards process used to eliminate non significant confounders if removal of a confounder changed the estimated OR by 10% it was kept in the model. Rates of **stillbirth** were higher among mothers living 50-150km and >150 km versus those living <50km from the hospital. No significant trend in the rate of still birth was observed after adjustment for confounding however. As distance increased risk of **perinatal death** increased even after adjustment for confounders (AOR 1.53; 95% CI 1.10 to 2.12): adjusted for parity, single parent status, low income neighbourhood, aboriginal status, smoking, alcohol, drug use during pregnancy, congenital anomalies, previous spontaneous abortions, induced abortions, male gender and suboptimal prenatal care. Distance to nearest hospital with caesarean section facilities <50km (n=27,836) perinatal death n=221 (0.8%)	**Author's conclusions:** Older women in rural versus urban areas had a lower rate of caesarean section and increased risk of perinatal death. The risk of perinatal death increased with distance to hospital. Further studies need to evaluate the contribution of underlying perinatal risks, access to care and decision making regarding referral and transport. **Comment:** The study authors noted the following limitations; inability to adjust for confounders such as maternal education, body mass index, assisted reproduction therapy, short interval between births (among multiparous women), stress, presence or lack of family support, nutrition and environmental factors. Study design means that a causal link between distance to services and adverse birth outcomes cannot be established. Unlikely to generalise to Welsh context because of possible ethnic/cultural differences between population studied and Wales population. Difference in healthcare delivery model

Study details	Overview	Author's conclusions & comments
	50-150km (n=1,534) perinatal death n=19 (1.2%) >150km n=328 perinatal death n=8 (2.4%) Rate of **NICU admission** did not show a significant difference by distance.	

Study details	Overview	Author's conclusions & comments
Case control – Finland – out of hospital delivery		
Ovaskainen K et al. 2015. **Out-of-hospital deliveries have risen involving greater neonatal morality**. *Acta Paediatrica* doi: 10.1111/apa.1311 **Study type:** Case control **Study Population:** Out of hospital deliveries in catchment area of single university hospital in Finland. 67 OHD in time period of these 52 included in analysis; 134 controls. Total births over duration 76,773 **Outcomes:** Out of hospital births, 5 minute Apgar scores, Hypothermia, infection small for gestational age, prematurity, hyperbilirubinaemia, hypoglycaemia, admissions to neonatal unit **Duration:** 1996 to 2011	**Study summary:** To investigate **trends and reason for out-of–hospital delivery** (OHD) in one university hospital catchment area. Data on cases and controls collected retrospectively from medical files. Home addresses at birth were taken from central population register. Travel distance between home and hospital calculated using a web based route planner – fastest route option was chosen. **Quality of study:** Case definition is not very clear**.** More robust design than cross sectional studies. Controls were deliveries immediately preceding and after OHDs. Distance was between mothers home and hospital – this is a strength but actual travel times not considered. Mothers were assumed to be at their normal residence at the onset of labour and hospital capacity was not considered as a reason for out of hospital deliveries. Deprivation, maternal educational status, maternal medical history and neonatal risk factors have not been adequately controlled for. **Findings:** 31 OHDs (46%) occurred on the way to the delivery unit, 22 (33%) outside the hospital and 1 (1.5%) was a planned home birth. The final model included smoking during pregnancy, duration of labour, living in partnership, previous pregnancies, maternal age, distance to the delivery unit, prenatal visits The following variables were associated with out of hospital delivery (no analysis for travel time to unit) **Distance to delivery unit at least 35 km OR 5.02 (95% CI 1.80-14.04)**. Smoking during pregnancy OR 6.54 (95% CI 1.33 to 32.22) Short duration of labour OR 18.79 (95% CI 5.96 to 59.29) Single-mother status) OR 13.01 (95% CI 3.37 to 50.23) Number of previous births OR 7.02 (95% CI 1.83 to 26.95) <13 prenatal visits OR 2.73 (95% CI 0.95 to 7.84)	**Author's conclusions:** OHDs were associated with poorer attendance at antenatal care, number of previous births, distance to delivery unit, maternal smoking, single status and higher infant morbidity. OHDs would thus seem to be poorly preventable. Hypothermia, need for hospitalisation, administration of antibiotics for infections and jaundice were common problems. OHDs are still rare in the catchment area of Tampere University Hospital but their incidence is increasing. We should therefore concentrate on the training of ambulance staff and develop and implement a protocol to educate attendants working in the alarm units. **Comment:** The authors noted the following limitations; small number of OHDs, missing values for maternal education or socioeconomic status or the use of alcohol or drugs. Data were based on self reports and found in only a small number of cases. No dose response is seen for increasing distance. Pre–publication paper in unedited form, no figures and results tables available. Study design means that a causal link between distance to maternity services and the outcomes of interest cannot be established. Potentially not generaliseable to Welsh setting. This study is on a single university hospital catchment population in Finland. There may be differences in the structure and delivery of healthcare.

Study details	Overview	Author's conclusions & comments
Cross sectional - Wales – infant mortality		
Paranjothy S et al.2014. **Perinatal outcomes and travel time from home to hospital. Welsh data from 1995 to 2009.** Acta Paediatrica; 103: e522-e527 **Study type:** Cross sectional **Study Population:** All registrable births (at least 24 weeks gestation) to women usually resident in **Wales** (n = 498 042). Exclusions ante partum stillbirths (n = 2419); lethal congenital anomalies (n=515); multiple pregnancies (n=13 820); records with invalid or missing gestations (n=4408); missing data on maternal age; (n=760), gender (n=16) postcode of mothers residence (n=5356) or hospital of birth (n=4503); 466 255 births available for analysis. 412 827 singleton births analysed **Outcomes:** Intrapartum stillbirth (death during labour, before birth); early neonatal death (death in first 6 days of life); late neonatal death (death at 7 to 27 completed days of life). **Duration:** 1995 to 2009	**Study summary:** Studied association between travel time from home to hospital and birth outcomes. Data obtained from All Wales Perinatal Survey (AWPS) and National Community Child Health Database (NCCHD). All births assigned lower super output area code based of grid reference of mother's residence postcode at time of birth. Address of each mother replaced by population weighted centroid[15]. Travel time was calculated using Google maps from there to the grid reference (postcode based) to the hospital **where birth took place and to each hospital open at that time** (including 4 outside Wales close to the border). Shortest travel times were calculated. **Quality of study:** See comments for authors limitations. AWPS described as fully ascertained with excellent data completeness – ranging from 100% for birthweight, gestation, mothers age and parity to 92% for maternal smoking. Overall data items for NCCHD described as 95% complete although this varies; in 2007 gestational age recording was 99% complete but smoking status was only 39% complete. The study analysed outcomes for both nearest hospital and actual delivery hospital. Travel times may underestimate actual travel time. Not clear how the final number of births analysed was obtained. Analysis not adjusted for some potential confounders including maternal smoking, birthweight, maternal and neonatal medical conditions/risk factors. Type of services provided by maternity facilities not defined. No rationale for why 15 minute travel time categories were chosen for analysis, do not know if this was determined *a priori* **Findings:** Multivariable logistic regression model used to obtain odds ratios for the association between travel time and each outcome variable. Analysis was on 412427 births. Odds ratios and CIs for differences in travel times are not given but for a composite outcome (all deaths combined) and adjusted for maternal age, social deprivation quintile, gestational age and other confounders (not specified) OR for 15 minutes were 1.15; 30 minutes 1.31 and 45 minutes 1.50. Odds ratios for every 15 minute increase in travel time adjusted for gestation, gender, maternal age, parity, social deprivation quintile and urban/rural index. **All births** **To actual hospital of birth**	**Author's conclusions:** Our study shows that the risk of an adverse birth outcome is increased with longer travel time to place of birth. However travel times to nearest hospital with maternity services were not significantly associated with increased risk of adverse pregnancy outcomes suggesting that the geographical location of maternity services may not affect the risk of adverse outcomes. **Comment:** The calculated travel time was based on the road network in 2012. Authors noted the following limitations; they did not have information on maternal smoking status, type of onset of labour, medical or surgical conditions affecting mother or baby and whether or not the baby had left hospital after birth in cases of neonatal deaths. They did not have information about maternal, foetal or pregnancy related conditions or risk factors that may have resulted in mothers opting to deliver at a more specialist hospital further away from their nearest facilities; this may considerably confound the results obtained for actual hospital of birth. This confounding would not be expected to be seen for the nearest hospital and there is no significant relationship for this analysis. Study design means that a causal link between distance to maternity services

[15] The centroid is a summary single reference point which represents how the population at census time was spatially distributed and grouped within that OA, LSOA or MSOA. The provision of centroids allows users to get consistent and comparable best-fit allocations to a higher geography using a geographical information system

Study details	Overview	Author's conclusions & comments
	Intrapartum stillbirth OR 1.13 (95% CI 0.98 to 1.30) n=135 Early neonatal death OR 1.13 (95% CI 1.07 to 1.20) n=609 Late neonatal death OR 1.15 (95% CI 1.05 to 1.26) n=251 Intrapartum still birth and neonatal death combined OR 1.15 (95% CI 1.09 to 1.20) n=995 **To nearest hospital** Intrapartum stillbirth OR 1.11 (95% CI 0.83 to 1.48) n=135 Early neonatal death OR 0.99 (95% CI 0.86 to 1.15) n=609 Late neonatal death OR 1.00 (95% CI 0.79 to 1.25) n= 251 Intrapartum still birth and neonatal death combined 1.01 (95% CI 0.90 to 1.13) n=995 **Term births** n=387 429 **To actual hospital of birth** Intrapartum stillbirth OR 1.36 (95% CI 1.17 to 1.59) n=85 Early neonatal death OR 0.97 (95% CI 0.80 to 1.17) n=177 Late neonatal death OR 1.34 (95% CI 1.13 to 1.59) n=77 Intrapartum still birth and neonatal death combined OR 1.19 (95% CI 1.06 to 1.32) n=339 **To nearest hospital** Intrapartum stillbirth OR 1.06 (95% CI 0.74 to 1.53) n=85 Early neonatal death OR 0.89 (95% CI 0.68 to 1.15) n=177 Late neonatal death OR 1.43 (95% CI 0.97 to 2.12) n=77 Intrapartum still birth and neonatal death combined OR 1.03 (95% CI 0.86 to 1.25) n=339 **Nulliparous women** n=185 419 **To actual hospital of birth** Intrapartum stillbirth OR 1.21 (95% CI 1.02 to 1.44) n=69 Early neonatal death OR 1.15 (95% CI 1.06 to 1.25) n=303 Late neonatal death OR 1.11 (95% CI 0.97 to 1.28) n=116 Intrapartum still birth and neonatal death combined OR 1.16 (95% CI 1.08 to 1.24) n=488 **To nearest hospital** Intrapartum stillbirth OR 1.00 (95% CI 0.66 to 1.45) n=69 Early neonatal death OR 1.00 (95% CI 0.82 to 1.22) n=303 Late neonatal death OR 0.98 (95% CI 0.71 to 1.36) n=116 Intrapartum still birth and neonatal death combined OR 0.99 (95% CI 0.85 to 1.17) n=448	and the outcomes of interest cannot be established. This study is based on Welsh data and is therefore highly applicable.

Study details	Overview	Author's conclusions & comments
Cross sectional		
Parker L, Dickinson H, Morton-Jones T. 2000. **Proximity to maternity services and still birth risk**. *Arch Dis Child Fetal Neonatal Ed*;82: F167-F168 **Study type:** Cross sectional **Study Population:** Singleton births in west Cumbria. 79,229 births of which 1234 were stillbirths **Outcomes:** Stillbirth (not further defined) **Duration:** 1 January 1950 to 30 September 1989	**Summary:** This study investigated whether **differences in the stillbirth** rate in west Cumbria could be explained by **increasing distance** from mother's residence to the first and second nearest maternity services. Data was extracted from a database of west Cumbrian births. Distance from mothers residence to services was calculated from grid references of postcode of mothers residence and maternity units open at the time. **Quality of study:** No information on the database from which births were extracted, no information on source or accuracy or of data. No information on a range of potential confounders for example maternal smoking and maternal and foetal medical conditions/risks. Type of services provided by maternity facilities not defined **Findings:** No significant increase in stillbirth risk was found with distance of mothers residence from the first or second nearest maternity services after adjusting for year of birth, fathers social class and birth order. The overall test of the distance effects showed no significant increase in risk with increasing distance from either the first or second nearest maternity services (p=0.5, 0.11 respectively)	**Author's conclusions:** The heterogeneity in the stillbirth risk in Cumbria cannot be accounted for by differences in ease of access to both routine **Comment:** Changes in the stillbirth rate mean that the findings of this study, based on data from 1989 and earlier, cannot be generalised to 2015 because of substantial changes in medical and maternal services and stillbirth rates.

Study details	Overview	Author's conclusions & comments
Cross sectional - France – Infant mortality		
Pilkington H et al. 2014. **Where does distance matter? Distance to the closest maternity unit and risk of foetal and neonatal morality in France**. *European Journal of Public Health*; 24(6); 904-9 **Study type:** Cross sectional **Study Population:** France. 26 860 still births, 3 086 128 live births 2002 – 2005. 6 202 918 live births, 14 860 neonatal deaths, 282 deaths after out of hospital births 2001-2008. Neonatal death all deaths before 28 days of life **Outcomes:** Still births foetal deaths ≥22 weeks gestation or ≥500 grams. Neonatal death all deaths before 28 days of life **Duration:** 2001to 2008 for births; 2002 to 2005 foetal deaths	**Study summary:** Investigated **impact of distance to closest maternity unit[16] on perinatal mortality**. Used vital statistic registry data based on birth certificate data. Death data from death certificates. Location of each maternity unit was geocoded and municipality of residence of mother was obtained from birth certificate and geocoded at centre of municipality. Distance was calculated according to major regional road networks. **Quality of study:** See comments for authors limitations**.** Some lack of clarity with regard to study population. No comment on general accuracy or completion of data source but missing data for 9.7% for type of pregnancy and 16.6% for maternal age. No information on some potential confounders for e.g. maternal smoking, maternal medical conditions, gestation and birthweight. Type of services provided by maternity facilities not defined. No rationale for why travel time categories were chosen for analysis, do not know if this was determined *a priori* **Findings:** No analysis of association between distance to nearest maternity unit and out of hospital births. No confidence intervals provided for relative risks. Distance to the closest maternity unit of 15-30 km and ≥ 45 km was associated with an increased risk of death after out of hospital birth after controlling for unemployment rate, % single-parent household, % foreign born population, maternal age and multiplicity. (note overlap of distance categories) **Stillbirth** Distance to nearest maternity unit <5 km Reference 5-15 km RR 0.99 15-30 km RR 1.01 30-45km RR 1.00 45+ km RR 1.08 **Neonatal mortality** Distance to nearest maternity unit <5 km Reference 5-15 km RR 0.91* 15-30 km RR 0.94 30-45km RR 0.90* 45+ km RR 0.96 **Neonatal deaths after out-of-hospital birth**	**Author's conclusions:** Further research should target these high-risk urban areas, characterised by higher levels of risk factors associated with stillbirths and neonatal mortality, with a view to better understanding causal mechanisms. Social and spatial accessibility should be explicitly and separately addressed in public health planning. **Comment:** The study authors noted the following limitations; different periods were used for the measures of mortality and data was missing for individual characteristics. Stillbirths were measured during a shorter time period than neonatal mortality. Data was missing for mother's age and type of pregnancy (singleton vs multiple). They could not distinguish between medical terminations of pregnancy and spontaneous foetal deaths. They did not know if out of hospital births were planned or accidental. No dose response is perceivable in any of the outcomes. Out of hospital deaths were calculated out of all births, this is therefore likely to be confounded by any relationship between distance and the chance of out of hospital deliveries; in this analysis, increased proportion of out of hospital deliveries in women living further away from facilities would lead to an apparent increased risk of death even if the mortality rate was uniform across all out of hospital deliveries. Study design means that a causal link between distance to maternity services and the outcomes of interest cannot be established. May not generalise to Welsh setting because of differences in the way which healthcare is provided.

[16] Most of these distance to nearest maternity unit – so not necessarily unit where delivery took place – is this an issue?

Study details	Overview	Author's conclusions & comments
	Distance to nearest maternity unit <5 km Reference 5-15 km RR 1.10 15-30 km RR 1.58* 30-45 km RR 1.51 45+ km 3.68* * authors note confidence interval does not include 1 Number of deaths after out of hospital birth was 282 (2001- 2008)	

Study details	Overview	Author's conclusions & comments
Cross sectional – Netherlands – infant mortality		
Ravelli ACJ et al. 2010. **Travel time from home to hospital and adverse perinatal outcomes in women at term in the Netherlands.** *BJOG* 118:457-65 **Study type:** Cross sectional **Study Population:** Netherlands, 751 926 singleton term hospital births; 69% of total births in time period **Outcomes :** Intrapartum mortality (death during labour before birth), neonatal mortality (death during the first 28 days of life); adverse neonatal outcomes (5 min Apgar <4, and/or transfer of newborn to NICU at birth) **Duration:** 2000 to 2006	**Study summary: Effect of travel time at start of or during labour, from home to hospital on mortality and adverse outcomes** in pregnant women in primary and secondary care. Excluded ante partum death, congenital abnormalities, records with missing details, home deliveries and hospitals that did not participate for the full 7 years of the study. Travel time was estimated using time needed to travel by road between the postal code of the woman's residence and postcode of the hospital or outpatient clinic where delivery took place. The data was from the Netherlands Perinatal Registry, was reported by authors to be validated but not specified how this was done. Reported that 4% of data is missing. **Quality of study:** Register based study. Actual place of departure unknown – authors suggest actual travel times are underestimated because no information on congestion etc. Type of transport not registered so the assumption was that it was by car. No data on some potential confounders, including maternal and neonatal medical conditions/risks, smoking and birth weight. Type of services provided by maternity facilities not defined, not clear what the difference is between outpatient and hospital clinics – deliveries occurred in both. No rationale for why travel time categories were chosen for analysis, do not know if this was determined *a priori* **Findings:** A slight increase in mortality (intrapartum and early or late mortality) was associated with a travel time to hospital of 20 minutes or more (which included intrapartum mortality (defined as death during labour before birth), and neonatal mortality (defined as death during the first 28 days of life) was associated with an increase in travel time to hospital (adjusted for gestational age, maternal age, parity, SES, ethnicity, urbanisation, tertiary perinatal centres and hospital birth rate) **Mortality** Travel time to hospital <15 minutes OR reference 15-19 minutes OR 0.94 (95% CI 0.79 to 1.12) ≥20 minutes OR 1.17 (95% CI 1.002 to 1.36) For death within 24 hours of birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.51 (95% CI 1.13 to 2.02) For death within 0-7 days after birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.37 (95% CI 1.12 to 1.67) For death 8 to 27 days after birth (adjusted as before) Travel time to hospital <20 minutes reference ≥ 20 minutes OR 1.24 (95% CI 0.67 to 2.27)	**Author's conclusions:** In women delivering at term in Netherland there is a significant association between a longer travel time (20 minutes or more) from home to the hospital and mortality or adverse outcomes. Further research is this field is necessary to investigate the policy implications for the Dutch obstetrical care system. **Comment:** Study design limits establishing a causal link between travel time to hospital and birth outcomes. May be generaliseable to a Welsh setting but differences in the way which healthcare is provided need to be considered.

Study details	Overview	Author's conclusions & comments
	There was a slight increase in **adverse outcome** (combined endpoint of mortality and/or 5 minute Apgar below 4, and/or transfer of newborn to neonatal intensive care unit at birth) adjusted as above Travel time to hospital < 15 minutes reference 15 -19 minutes OR 1.11 (95% CI 1.02 to 1.21) ≥20 minutes OR 1.27 (95% CI 1.17 to 1.38)	