This manuscript has not been submitted for publication. It describes the linkage of four administrative datasets to examine blood transfusion in mothers, and compares the study population created with all births in NSW public hospitals. By placing the results on this repository we are hoping to provide details of each dataset and highlight strengths and limitations of using these linked data.

Linkage of four administrative datasets to examine blood transfusion in pregnancy

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Abstract:

Currently collected hospital data records fact of transfusion, but lacks detail on quantity of blood transfused, and timing of transfusions. A number of administrative datasets collect information on blood transfusion including quantity and timing. Linkage of multiple datasources has the potential to give increase the depth of information available for researchers. This study aims to describe the linkage of four administrative datasets to identify transfusions among women giving birth in NSW and to describe the population represented by this linked data.

Hospital, birth, blood issue and blood pack databases were linked to identify women receiving red blood cell transfusions in NSW between July 2006 and December 2010. Characteristics of the linked data population are compared with the population of all women giving birth, and births in public hospitals.

Between July 2006-December 2010 there were 425,036 births in NSW hospitals, including 235,796 in a population with additional blood issue data available, of which, 4642(2%) received a transfusion. Hospitals supplying blood issue data were more likely to be larger urban or tertiary hospitals, and had a higher risk population than the state overall and public hospitals generally.

Linkage of multiple data sources provides additional detail compared with hospital data alone, providing a wealth of data for researchers. The population identified through linkage differs from the overall birthing population, and to a lesser extent from women birthing in public hospitals. In some cases this may affect generalisability of research findings, but in other cases may be beneficial.

Introduction

Red blood cell transfusion is used in pregnancy to treat anaemia and as a potentially life-saving intervention in the presence of ongoing bleeding. Most commonly in obstetrics, transfusion is used in the management of postpartum haemorrhage (PPH). Trends in transfusion rates have been used to explore the increase in PPH over time and to investigate whether the severity of PPH is increasing.[1-3]

A number of studies have examined population trends in transfusion using routinely collected hospital data.[4-7] However, lack of data on quantity transfused in population datasets limits their use in assessing severity of PPH, and also in evaluating changes in hospital practice related to the volume of blood given (such as the Single Unit Transfusion Policy). [8]

Hospital based studies, particularly those involving medical record review, frequently have access to more detail, including data on the number of units transfused.[9-11] Such studies however are not always generalisable, depending on the patient mix of the hospital. A further limitation of hospital based studies is the small number of women included, given the small proportion of women who receive a transfusion, which limits the power for statistical analyses, and may prevent adequate risk factor adjustment. Small numbers are particularly a limitation in studies interested in examining potentially rare outcomes related to transfusion.

When information on quantity of blood transfused is collected by a central body, and includes some form of patient identifiers, it may be possible to link this data with routinely collected hospital data to assess patient outcomes. In 2006, the New South Wales Clinical Excellence Commission commenced the Red Cell Utillisation database as part of their Blood Watch program. [12] Blood banks of hospitals participating in the program submitted data on each red cell transfusion occurring that month, including the medical record number of the patient receiving the transfusion. In NSW, data on hospital admissions is also routinely collected by the Ministry of Health. By linking the data provided by these two databases, it is possible to calculate the number of transfusions received by a patient during their hospital stay. This linkage process is completed by a third party, using privacy preserving principles, so that risk of identification of patients to researchers is minimised. [13,14] Linkage to further databases, such as the Perinatal Data Collection records of births, and the Australian Red Cross Blood Service blood pack database is also possible using similar techniques, allowing for identification of births and inclusion of more detailed birth data than available in hospital records, as well as including additional information such as blood type and blood collection date.

It is important before using linked data to understand how the population included in the linked data differs from the general population, and hence affects the generalisability of the findings. This study aims to compare the characteristics of populations of birthing women identified in the Blood Watch database with the NSW population generally, and women giving birth in public hospitals.

Methods:

This project utilised data from four administrative data sets to define the population of women who gave birth in NSW hospitals, examine their associated medical conditions, the number of transfusions they received, and obtain information on the type and age of blood they received. These datasets were: the Perinatal Data Collection ('birth data'), the Admitted Patient Data Collection ('hospital data'), the Blood Watch program database ('Blood Watch data') and the Australian Red Cross Blood Service data ('Red Cross data') (Figure 1). The study population was all women giving birth to an infant(s) of at least 20 weeks gestation in NSW hospitals between July 2006-December 2010. In NSW obstetric care is offered in both public (government owned) and private hospitals, and women can choose to attend a public hospital as a public or private patient, or to receive care in a private hospital.

Births were identified from the *Perinatal Data Collection* ('birth data'), a statutory collection of all births in NSW of at least 20 weeks gestation or 400g birthweight. This dataset contains information on the pregnancy, labour and delivery and is reported by the midwife or clinician attending the birth. [15] Information on maternal medical conditions, including transfusion, is available from the *Admitted Patients Data Collection* ('Hospital data'), which records procedures and diagnoses associated with all admissions to NSW hospitals. Up to 50 procedures and diagnoses are coded from the medical record according to the Australian Classification for Health Interventions, and the International Classification of Disease version 10, Australian Modification, respectively. [16,17] Red cell transfusion is recorded in the procedure codes as transfusion of packed cells or whole blood. Although more than one transfusion may occur during an admission, procedure coding contains only fact of transfusion. The birth and hospital data are statewide data collections, including information on women giving birth in both public and private hospitals.

Between 2006 and 2010 information on red cell transfusion in public hospitals was also available from the Clinical Excellence Commission's *Blood Watch* program. The NSW Clinical Excellence Commission is a government body overseeing safety and quality improvement programs in the public hospital system. One such program is the Blood Watch program, aimed at "sustainable,

responsible, safe and appropriate use of blood and blood products." [12] During this period public hospital blood banks were required to submit a record of each blood pack which was issued, containing blood pack barcode, issue date, and patient medical record number. Hospital participation in this program was staggered, with not all hospitals submitting data each month. A comparison group of non transfused women was formed by identifying which hospitals submitted data on at least one woman who was transfused in a given month, and including all births in those hospitals for that month. Women were classified as being in the Blood Watch data if they gave birth in a hospital in a month where it was submitting data to the Blood Watch program. This data was then linked deterministically with the *Australian Red Cross Blood Service database* to obtain information on the blood product transfused including collection date and blood group. This allowed for both fact and quantity of transfusion to be identified. The Australian Red Cross Blood Service database records details about each blood pack processed and issued by the Blood Service, the collection date and time, any transformation steps taken, the product type, storage solution, blood type, expiry date and time, hospital receiving the blood, date and time of issue. This data is used by the blood service to facilitate product supply.

The birth, hospital and Blood Watch data were probabilistically linked to identify birth admission related records across all databases belonging to the same woman. Derivation of the study population is shown in Figure 2. It should be noted that all Blood Watch births are also included in the public hospital group in analysis. Comparisons are made between the NSW maternity population, and the population delivering in public hospitals (which most closely reflects the population that the Blood Watch data was drawn from).

Maternal and pregnancy characteristics were identified from the birth and hospital data, as appropriate. [18] Socioeconomic status was defined using quintiles of the Socioeconomic Index for Areas index of disadvantage for the area of residence of the woman. [19] To enable comparison of red cell transfusion rates between groups, transfusion was identified from the hospital data, which is known to slightly underestimate transfusions (sensitivity 83.1 (95% CI 52.2,97.7)),[20] but is available for women outside the Blood Watch data. Hospitals were grouped according to size and location (regional, large urban/tertiary, smaller urban), and according to their 'maternity service level' reflecting their capacity to care for women and infants at varying degrees of risk. [21]

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee. All analyses were performed in SAS 9.3.

Results

Between July 2006 and December 2010 there were 425,036 births in 121 NSW hospitals, 98.7% linked to a corresponding hospital admission. There were 317,958 public hospital births (75.8%), with corresponding Blood Watch data was available for 235,796 (74.1%), including 4642 (2.0%) women receiving a transfusion. The Blood Watch data was deterministically linked with the Red Cross Blood issue data for 3456 (74.4%) of transfusions. Blood pack barcode information was corrupted or missing for the remaining cases precluding a higher linkage rate (Figure 2). This missing information related to packs predominantly issued within one local health district.

Women in the Blood Watch data were similar in age, distribution of maternal medical conditions, pregnancy characteristics, and gestational age compared to the NSW maternity population overall, but were more likely to be of lower socioeconomic status, and giving birth in tertiary hospitals (Table 1). Women giving birth in Blood Watch hospitals were similar to women giving birth in public hospitals generally, although with lower rates of postnatal maternal transfer, higher proportions of births in tertiary centres and lower rates of births in regional centres. Red blood cell transfusion rates were higher in women delivering at Blood Watch hospitals compared with the NSW maternity population and public hospitals. The proportion of births included in the Blood Watch data increased over time.

During the study period, 67 out of 121 maternity hospitals submitted data to the Blood Watch database. The median number of births per year in Blood Watch hospitals was higher than in public hospitals generally. Rates of caesarean section were similar between Blood Watch and public hospitals, however Blood Watch hospitals tended to have higher PPH rates and transfusion rates (Table2). All of the hospitals offering tertiary obstetric care submitted data, however only 32% of smaller urban hospitals and 83% of regional hospitals submitted data (Table 3).

Discussion

Between July 2006 and December 2010, hospitals participating in the Blood Watch program saw over half of all birthing women in NSW hospitals, and around three-quarters of women birthing in public hospitals. The Blood Watch sample did not differ considerably from women birthing in public hospitals, but represented a slightly higher risk group of women when compared to NSW birthing women overall. By covering a large proportion of births in the state, the Blood Watch data linked with hospital and birth data contains a large number of transfused mothers for statistical analysis, and provides a useful additional data source for analysis.

The main differences between the Blood Watch data and overall NSW hospital births were a higher transfusion rate in Bloodwatch hospitals, and a larger proportion of births in tertiary hospitals with associated increased rates of higher risk pregnancies. Because we could not differentiate between hospitals with no transfusions in a month, and hospitals which did not submit data to the Blood Watch program in that time, we may have biased our sample towards hospitals with higher transfusion rates, excluding smaller hospitals where transfusion is rare. Therefore, tertiary and larger urban hospitals, with higher numbers of births were more likely to be included in the sample. These hospitals however are also the hospitals with the facilities to manage higher risk pregnancies, and so the study population in the Blood Watch data is likewise reflective of a higher risk population. Similarly, the Blood Watch data differs in several ways from the population of women giving birth in public hospitals generally. Consistent with an overrepresentation of larger and tertiary hospitals, and an underrepresentation of regional hospitals, births in the Blood Watch data tend to be higher risk with higher proportions of births at early gestations, multiple births and mothers with gestational diabetes. Lower rates of maternal postnatal transfer are seen, consistent with the larger hospitals being able to manage these cases without transfer.

The effect of these biases on the extent to which generalisations to the general population can be made from findings based on the Blood Watch data, depends on the research question. Descriptive analysis such as questions of prevalence of transfusion and quantity of transfusion will be limited by the differences between the Blood Watch and general population, particularly due to the higher risk Blood Watch Population, which would result in an overestimate of transfusion rates. Questions relating to risk factors, such as time between blood donation and transfusion, and risk factors for quantity of blood transfused however can be addressed using these data, provided there is no clinical or scientific reason to believe that the effect of these risk factors should differ between population groups, beyond what is accounted for in statistical modelling. Provided potential

confounders are controlled for, conclusions from such analyses are valid.[22,23] The analysis of trends over time is limited by the inconsistent nature of reporting by hospitals.

The Blood Watch data lacks data on private hospitals; and regional hospitals are under-represented. In NSW, approximately 25% of births occur in private hospitals and 20% in regional hospitals. In addition to differences in patient casemix noted above, it is known that clinical practice differs by hospital type, particularly with transfusion rates being lower in private hospitals.[24,25] This means that the Blood Watch data is limited in its use for examining health services research questions such as transfusion practice, and adherence to policies, outside of the urban, public hospital setting. The linked data however provides a greater detail of depth than hospital data alone, which makes it ideal for examining such questions within larger urban hospitals. Linkage with pathology laboratory haemoglobin testing has been used to examine the frequency at which transfusions are occurring outside of specified guidelines. [26]

This study makes use of routinely collected data linked with data collected as part of program monitoring, to provide information on transfused women that includes more detail than is available in a single dataset. Although hospital data contains information on fact of transfusion, it lacks detail including on the quantity of blood transfused, which has been recognised as a limitation in previous studies. [24,27] Through linkage with the Blood Watch data, this limitation has been overcome for a large proportion of the population. The feasibility of linkage of blood bank issue data and hospital or birth records for obstetrics has also been investigated in France, [28,29] and found to be possible, and to give higher ascertainment of transfusion than hospital data alone. Sagot *et al.* found that identification of severe postpartum haemorrhage with transfusion was improved using blood issue data linked with birth records. [29] The NSW linked hospital, birth, blood issue and blood pack datasets have been used to examine outcomes related to age of blood transfused, utilising collection date from the blood pack data, and number of transfusions from the blood pack data.[30] Such a study would not be possible without the larger sample size allowed by the linked dataset. Outside of transfusion, data linkage of hospital and registry or other databases has been used successfully to examine a wide range of outcomes including birth defects, [31] hip fractures,[32] and renal-failure.[33] Such projects would have been difficult or infeasible using single datasets, due to difficulties with followup, recall bias, insufficient information and cost. Use of data linkage allows for a larger sample to be obtained than would be feasible in a study based on medical record review, but provides additional data compared with what is available in routinely collected data.

Use of linked data however has some potential limitations. In this study, we have drawn our comparison group of non-transfused women from hospitals who submitted some data to the Blood Watch system during that month. This means that we may have falsely excluded some smaller hospitals which had no obstetric transfusions in a month, but who had submitted data to the Blood Watch program that month for other specialties. Another limitation of the Blood Watch data is that all units are assumed to have been transfused, if there is no note that it was returned to the blood bank. In a small proportion of cases, blood may have been issued for a woman, not transfused, and not noted as returned in the blood bank. A previous study using the datasets described here found that restricting the study population to women having an increase in haemoglobin (indicating that the transfusion had been given) did not change the conclusions from the study. [30] Administrative datasets also need to be validated against medical records to quantify any underreporting that may be present. Variables considered in this study from the birth and hospital data have previously been validated,[18] however number of packs (from the Blood Watch data) has not been validated against medical records.

The NSW Blood Watch program data can be used to provide extra information on number of blood transfusions given during public hospital admissions for delivery. The study population created by linking Blood Watch and routinely collected hospital, birth and blood issue data is representative of women birthing in public hospitals. Data linkage has the potential to provide a greater level of detail than available from a single data source, while maintaining a larger sample size than is feasible from a medical record review or hospital based study. There is also the potential of adding more detail, such as pathology reports or blood pack information on age of blood or blood type, where these datasets exist.

Table 1: Maternal and pregnancy characteristics of all births in all NSW hospitals, births within public and private hospitals, and the Blood Watch hospitals.

Category	Code	All births N (Col%)	Private hospitals N (Col%)	Public hospitals N (Col%)	Blood Watch N (Col%)
Total (row%)		419538 (100.0)	101580 (24.2)	317958 (75.8)	235796 (56.2)
Maternal Age	Under 20	14690 (3.5)	178 (0.2)	14512 (4.6)	9642 (4.1)
	20-34	306470 (73.0)	66882 (65.8)	239588 (75.4)	176623 (74.9)
	35+	98351 (23.4)	34510 (34.0)	63841 (20.1)	49524 (21.0)
Private patient	Yes	141688 (33.8)	101580 (100.0)	40108 (12.6)	29138 (12.4)
SEIFA	Most disadvantaged	91957 (21.9)	8315 (8.2)	83642 (26.3)	66680 (28.3)
	2	78993 (18.8)	9685 (9.5)	69308 (21.8)	43672 (18.5)
	3	75877 (18.1)	16927 (16.7)	58950 (18.5)	41434 (17.6)
	4	83221 (19.8)	24075 (23.7)	59146 (18.6)	47937 (20.3)
	Least disadvantaged	79685 (19.0)	39427 (38.8)	40258 (12.7)	31140 (13.2)
Pregnancy characteristics	Multifetal pregnancy	6321 (1.5)	1462 (1.4)	4859 (1.5)	3991 (1.7)
	Primiparous	176443 (42.1)	45196 (44.5)	131247 (41.3)	100008 (42.4)
Medical conditions	Gestational Diabetes	25715 (6.1)	5003 (4.9)	20712 (6.5)	16793 (7.1)
	Pregnancy hypertension	31096 (7.4)	6962 (6.9)	24134 (7.6)	17903 (7.6)
	Bleeding or platelet disorder	3956 (0.9)	756 (0.7)	3200 (1.0)	2437 (1.0)
	Placenta praevia	4061 (1.0)	1382 (1.4)	2679 (0.8)	2181 (0.9)
	Postpartum haemorrhage	31683 (7.6)	4227 (4.2)	27456 (8.6)	21335 (9.0)
	Antepartum haemorrhage	4896 (1.2)	783 (0.8)	4113 (1.3)	3369 (1.4)
	Morbidly adherent placenta	1044 (0.2)	318 (0.3)	726 (0.2)	542 (0.2)
Gestational Age	<=32 weeks	6749 (1.6)	362 (0.4)	6387 (2.0)	5577 (2.4)
	33-36 weeks	21278 (5.1)	4505 (4.4)	16773 (5.3)	12906 (5.5)
	37+ weeks	391511 (93.3)	96713 (95.2)	294798 (92.7)	217313 (92.2)
RBC transfusion	Yes	5730 (1.4)	680 (0.7)	5050 (1.6)	4166 (1.8)
Mode of birth	Caesarean	125741 (30.0)	40887 (40.3)	84854 (26.7)	64439 (27.3)
	Non-instrumental vaginal	244442 (58.3)	44886 (44.2)	199556 (62.8)	145709 (61.8)
	Instrumental	47982 (11.4)	15654 (15.4)	32328 (10.2)	24678 (10.5)

Maternal Transfer (postnatal)	Yes	11644 (2.8)	1228 (1.2)	10416 (3.3)	5690 (2.4)
Hospital type	Larger Urban/Tertiary	175657 (41.9)	0 (0.0)	175657 (55.2)	153468 (65.1)
	Regional	87893 (20.9)	0 (0.0)	87893 (27.6)	42781 (18.1)
	Smaller Urban	54408 (13.0)	0 (0.0)	54408 (17.1)	39547 (16.8)
	Private	101580 (24.2)	101580 (100.0)	0 (0.0)	0 (0.0)
Year	2006	45957 (11.0)	11039 (10.9)	34918 (11.0)	21550 (9.1)
	2007	93065 (22.2)	21952 (21.6)	71113 (22.4)	48714 (20.7)
	2008	93137 (22.2)	22528 (22.2)	70609 (22.2)	51687 (21.9)
	2009	93632 (22.3)	23159 (22.8)	70473 (22.2)	55120 (23.4)
	2010	93747 (22.3)	22902 (22.5)	70845 (22.3)	58725 (24.9)

Table 2: Hospital rates for hospitals reporting to the Blood Watch program compared with public hospitals

	Blood Watch Data (Median, IQR)	Public hospital births (Median, IQR)
Average births per annum	446 (186, 1350)	240 (94, 1024)
PPH rate	8.3 (6.3, 10.0)	6.8 (4.0, 8.9)
% private patients	9.1 (3.9, 19.7)	7.0 (1.0, 18.3)
Transfusion rate	2.0 (1.4, 3.5)	1.1 (0.0, 1.8)
% Spontaneous vaginal deliveries	49.6 (44.1, 54.2)	51.3 (46.2, 70.4)
CS rate	25.0 (19.9, 30.3)	23.6 (9.3, 28.1)

Table 3: Characteristics of hospitals reporting to the Blood Watch program compared with public hospitals

	Blood Watch Data (N hospitals)	**Public hospital births (N hospitals)**
Hospital Type		
Large Urban/Tertiary	12	12
Regional	43	52
Urban/other	12	38
Obstetric level		
1 –Postnatal Care	2	23
2- Low risk births	9	14
3- Low and selected moderate risk births	26	33
4- Moderate risk births	13	15
5- High risk births	10	10
6- Tertiary centres	7	7

This table is based on characteristics of hospitals which reported to the CEC at least once over the time period.

Transfusion in Mothers

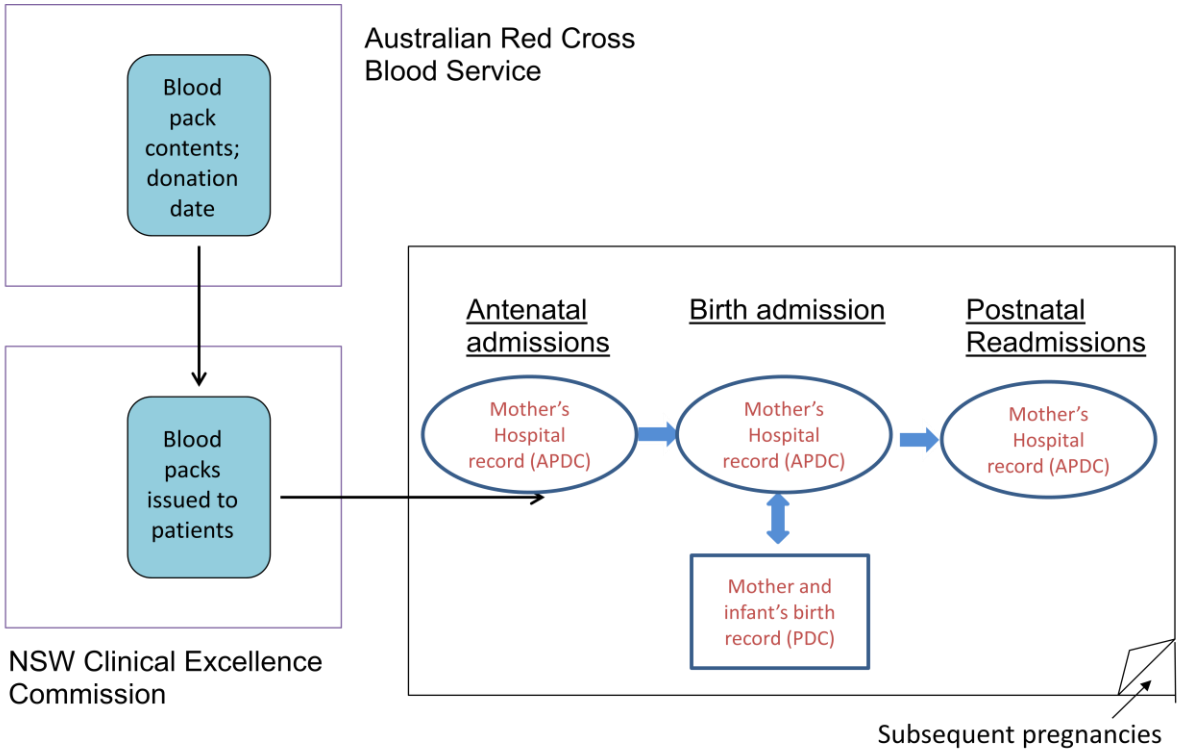

Figure 1: Diagram showing linkage of Blood Watch, Red Cross, Hospital and Birth datasets.

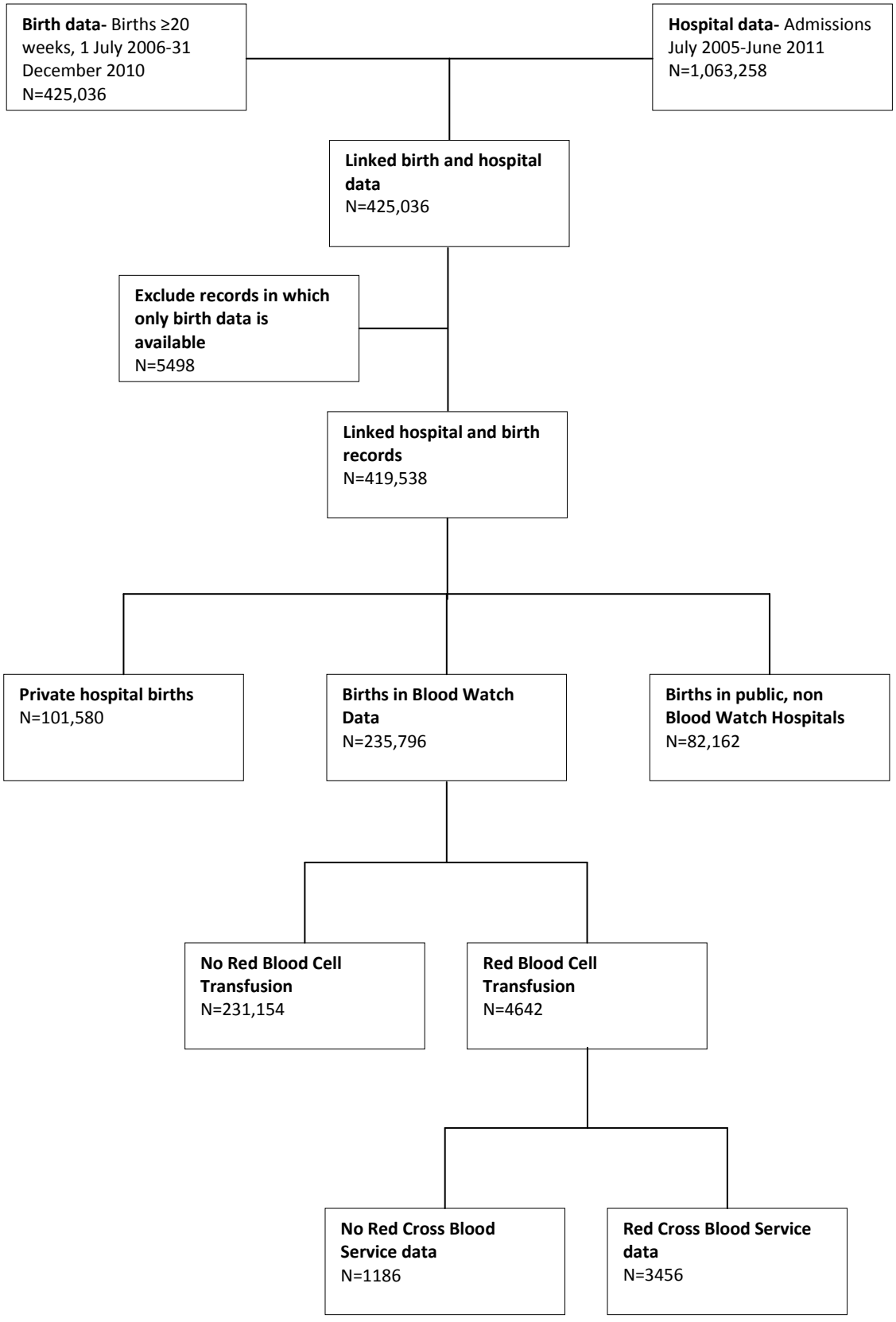

Figure 2: Flowchart of study population derivation

Transfusion in Mothers

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