

# Interventional radiology in obstetric patients: A population-based record linkage study of use and outcomes

Heather J. Baldwin<sup>1,2</sup> | Deborah A. Randall<sup>1,2</sup>  | Richard Maher<sup>3</sup> | Simon P. West<sup>4,5</sup> |  
Siranda Torvaldsen<sup>1,2,6</sup> | Jonathan M. Morris<sup>1,2,4</sup> | Jillian A. Patterson<sup>1,2</sup> 

<sup>1</sup>The University of Sydney Northern Clinical School, Women and Babies Research, St Leonards, New South Wales, Australia

<sup>2</sup>Northern Sydney Local Health District, Kolling Institute, St Leonards, New South Wales, Australia

<sup>3</sup>Department of Radiology, Royal North Shore Hospital, St Leonards, New South Wales, Australia

<sup>4</sup>Department of Obstetrics and Gynaecology, Royal North Shore Hospital, St Leonards, New South Wales, Australia

<sup>5</sup>The University of Sydney, Sydney Medical School- Northern, St Leonards, New South Wales, Australia

<sup>6</sup>School of Population Health, UNSW, Sydney, New South Wales, Australia

## Correspondence

Jillian A. Patterson, Women and Babies Research, Level 5, Douglas Building, Royal North Shore Hospital, Reserve Road, St Leonards, 2065 NSW, Australia.  
Email: [jillian.patterson@sydney.edu.au](mailto:jillian.patterson@sydney.edu.au)

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## Abstract

**Introduction:** Interventional radiology (IR) is a technique for controlling hemorrhage and preserving fertility for women with serious obstetric conditions such as placenta accreta spectrum (PAS) or postpartum hemorrhage. This study examined maternal, pregnancy and hospital characteristics and outcomes for women receiving IR in pregnancy and postpartum.

**Material and methods:** A population-based record linkage study was conducted, including all women who gave birth in hospital in New South Wales or the major tertiary hospital in the neighboring Australian Capital Territory, Australia, between 2003 and 2019. Data were obtained from birth and hospital records. Characteristics and outcomes of women who underwent IR in pregnancy or postpartum are described. Outcomes following IR were compared in a high-risk cohort of women: those with PAS who had a planned cesarean with hysterectomy. Women were grouped by those who did and those who did not have IR and were matched using propensity score and other factors.

**Results:** We identified IR in 236 pregnancies of 1 584 708 (15.0 per 100 000), including 208 in the delivery and 26 in a postpartum admission. Two-thirds of women receiving IR in the birth admission received a transfusion of red cells or blood products, 28% underwent hysterectomy and 12.5% were readmitted within 6 weeks. Other complications included: severe maternal morbidity (29.8%), genitourinary tract trauma/repair (17.3%) and deep vein thrombosis/pulmonary embolism (4.3%). Outcomes for women with PAS who underwent planned cesarean with hysterectomy were similar for those who did and did not receive IR, with a small reduction in transfusion requirement for those who received IR.

**Conclusions:** Interventional radiology is infrequently used in pregnant women. In our study it was performed at a limited number of hospitals, largely tertiary centers, with the level of adverse outcomes reflecting use in a high-risk population. For women with

**Abbreviations:** ACT, Australian Capital Territory; CI, confidence interval; IR, interventional radiology; PAS, placenta accreta spectrum; NSW, New South Wales.

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PAS undergoing planned cesarean with hysterectomy, most outcomes were similar for those receiving IR and those not receiving IR, but IR may reduce bleeding.

#### KEYWORDS

balloon occlusion catheterization, obstetric hemorrhage, pelvic arterial embolization, placenta accreta spectrum, postpartum hemorrhage, radiology

## 1 | INTRODUCTION

Interventional radiology (IR) is a technique for preventing or controlling hemorrhage that is being used more commonly in serious obstetric conditions such as placenta accreta spectrum (PAS) or massive postpartum hemorrhage. When bleeding cannot be controlled by the usual means, a clinician can resort to advanced surgical techniques such as uterine compression sutures, arterial ligation or hysterectomy. IR is an alternative intervention that aims to reduce risks posed by more radical or complex surgery, and to preserve fertility by avoiding hysterectomy.<sup>1</sup> IR is used prophylactically where a woman is considered at high risk of peripartum hemorrhage, such as suspected PAS, and in emergency scenarios to treat unexpected major bleeding. In prophylactic use, occlusion balloon catheters are placed in either the common iliac, internal iliac or uterine arteries prior to planned cesarean delivery, to be inflated if and when required.<sup>2</sup> If inflation of occlusion balloons does not successfully treat the hemorrhage, the presence of the catheters facilitates rapid progression to transcatheter arterial embolization.<sup>2</sup> In emergency settings, transcatheter embolization of the internal iliac arteries or uterine arteries may be considered in patients with persistent bleeding not responding to standard medical and surgical treatments, potentially avoiding the need for further surgery or hysterectomy.<sup>3,4</sup>

Current obstetric guidelines state that more evidence is needed to determine whether use of IR is of clinical benefit.<sup>5-8</sup> The literature on IR in obstetrics largely comprises case reports and studies with limited sample sizes.<sup>9,10</sup> Mixed results have been reported, with some studies showing reduced blood loss and transfusion requirements and decreased morbidity, and others finding no benefit.<sup>9,10</sup> Complications reported include maternal thromboembolic events, non-target embolization causing devascularization of organs such as the bowel, ureter and bladder, and patients requiring stent replacement and/or arterial bypass.<sup>9</sup> Safety concerns have been raised regarding fetal exposure to ionizing radiation.<sup>6</sup> Anecdotal evidence suggests that the use of IR in obstetrics is highly variable by hospital and clinician.

This study has two aims: to investigate how and where IR is being used in obstetric patients in hospitals in Australia, and to examine outcomes for women receiving this treatment. This will inform future management of women through providing evidence on the benefits or potential harms of this form of management.

#### Key message

Interventional radiology to control bleeding is likely safe in pregnancy and postpartum, although more evidence is needed to support its potential benefits.

## 2 | MATERIAL AND METHODS

Women who gave birth to a liveborn or stillborn infant(s) at all hospitals in New South Wales (NSW) from 2003 to 2019 or in the tertiary maternity hospital in the Australian Capital Territory (ACT) between 2004 and 2017 were included. Births in the ACT were included in order to capture high-risk women who may have been cared for in this tertiary center due to proximity. The NSW and ACT births represent approximately one-third of Australian births.

Maternal and neonatal characteristics, pregnancy, labor and birth data were obtained from the NSW and ACT Perinatal Data Collections, which record all births of at least 400 g birthweight or 20 weeks' gestation. Data on IR, risk factors, comorbidities, other covariates and outcomes were obtained from the Admitted Patient Data Collections, which are a census of all hospital admissions for each state/territory. These datasets contain diagnoses and procedures coded using the International Classification of Diseases 10th Revision Australian modification and the Australian Classification of Health Interventions, 8th Edition.

The data were linked by the NSW Centre for Health Record Linkage using probabilistic methods based on personal identifiers. Unique project identifiers were assigned to each mother, allowing for longitudinal linkage of hospitalizations during and following pregnancy. Rates of missed and incorrect links are <5 per 1000.<sup>11</sup>

IR was identified using the procedure codes "35321-06", transcatheter embolization of blood vessels, pelvis (available from 2008), and "35321-00" transcatheter embolization of a blood vessel (available prior to 2008) in admissions that occurred (a) during the birth admission (including transfers), (b) during a postpartum readmission (up to 6 weeks after birth), (c) antenatally (from 20 weeks).

Characteristics included age, socioeconomic status,<sup>12</sup> obstetric hemorrhage, PAS, placenta previa, blood disorders, pregnancy hypertension and preeclampsia, iron deficiency anemia, gestational

diabetes, mode of birth, gestational age at birth, and small and large for gestational age. Hospitals were grouped by type into tertiary hospitals (tertiary public hospitals with a neonatal intensive care unit able to care for neonates from 23 weeks), other public hospitals, and private hospitals. Hospitals were also grouped according to region (urban or rural).

Maternal outcomes considered were: readmission, blood transfusion, severe maternal morbidity, genitourinary tract injury/repair (including fistula, bladder obstruction, bladder repair, cystotomy, repair of intestines), sepsis, thrombosis or embolism, length of stay in the birth admission, readmission to hospital within 6 weeks, hysterectomy or death within 6 or 12 months of birth. Severe maternal morbidity was measured by a validated composite indicator,<sup>13</sup> with blood transfusion, hysterectomy and related components excluded and reported separately.

To enable comparison of outcomes of women receiving IR, a high-risk subset was formed. This group was all women with a diagnosis of PAS undergoing a planned cesarean section and a hysterectomy in the birth admission. These are most likely a planned cesarean hysterectomy; however, it is not possible to determine from the hospital record whether the hysterectomy was planned prior to admission. Propensity score matching was used to match women receiving IR to similar women within the high-risk subset who did not receive IR, resulting in two groups having a similar balance of measured risk factors, with the remaining difference being exposure to IR. Propensity scores were calculated using logistic regression with IR in the birth admission as the outcome variable. Known risk factors were identified from the literature and clinical input and were included as covariates if they were suspected to be associated with the outcomes.<sup>14</sup> Covariates included maternal age (<35 or ≥35 years), primiparity, hospital location, smoking and placenta previa with exact matching on grouped years (with 2008 divided based on the introduction of the procedure code change), and hospital group, which was based on annual birth volume, location, public or private, and NICU status.<sup>15</sup> Nearest neighbor, 1:1 matching without replacement was performed. Data management and analysis was performed in SAS Version 9.4. Records with missing data were excluded from analyses involving that variable.

## 2.1 | Ethic statement

Ethics approval for this study was granted by the NSW Population and Health Services Research Ethics Committee (2012/12/430) on August 27, 2020.

## 3 | RESULTS

There were 1 584 708 births of neonates of at least 20 weeks' gestation or 400 g birthweight in New South Wales ( $n = 1\,546\,548$ ) and Australian Capital Territory ( $n = 38\,160$ ) during 2003–2019, among 926 551 women. There was a total of 237 IR procedures recorded

among 236 pregnancies (0.01%) (Table 1). Of these, 208 were recorded during the birth admission and 26 during a postpartum readmission. Procedures in the antenatal period were rare ( $n < 5$ ) and are not discussed further.

Characteristics for women who received obstetric IR during the birth admission or postpartum readmission compared with women who did not, are shown in Table 1. Women who received IR tended to be older and were less likely to be born in Australia. Postpartum hemorrhage occurred in 72.1% of women who had IR during a birth admission and 88.5% of women who had IR during a postnatal admission, compared with 9.6% of women who had no IR. PAS was present in 81 (38.9%) women who had IR during the birth admission compared to 0.3% in those who had no IR.

The majority (63.5%) of women who had IR during the birth admission and 42.3% of women who had IR during a postnatal readmission underwent the procedure in a tertiary hospital. Among public hospitals, pregnancy-related IR was performed in 18 of around 220 hospitals, with the majority (68.0%) of procedures occurring at five hospitals; the mean number of IR procedures performed in those hospitals was 10.9 and the maximum was 45.

Around two-thirds of women receiving IR during the birth admission also had a transfusion of red blood cells or blood product, almost 30% underwent hysterectomy or experienced severe morbidity, 18% experienced genitourinary tract injury/repair and 12.5% were readmitted (Table 2). There were no deaths within 6 weeks among those receiving IR.

When considering women with PAS who underwent a planned cesarean with hysterectomy, 44 women who had IR in a birth admission were matched to women not having IR (Table 3; the standardized difference in the logit of propensity score was 0.44 before and 0.001 after matching). Almost 80% of these procedures were performed in tertiary hospitals. Among this cohort, there was a slight reduction in blood transfusion for those undergoing IR (Table 4). Women undergoing IR had higher rates of morbidity, genitourinary tract injury or repair, thrombosis or embolism, but lower rates of length of stay greater >5 days, although this was not statistically significant. The increased morbidity in those undergoing IR was mainly due to higher rates of bladder repair within this group (13 in the IR group vs 7 in the non IR group).

## 4 | DISCUSSION

This population-based study found that IR in pregnancy is uncommon, occurring in 14.9 per 100 000 pregnancies. IR primarily occurs during the birth admission, but also is used in the postnatal context, but rarely antenatally. Most procedures occur in a tertiary hospital; however, more than one-third of procedures were performed at other public and private facilities. Approximately one-quarter of women who had IR at birth also had PAS and underwent a planned cesarean with hysterectomy, suggesting that these IR procedures were planned, whereas the remaining procedures may have been performed in an emergency setting. Women

**TABLE 1** Maternal and pregnancy characteristics for women who did and did not receive pelvic interventional radiology during the birth admission or postpartum period, in New South Wales and Australian Capital Territory, 2003–2019

Characteristic	Code	IR in the birth stay		IR postnatally		No IR	
		n	%	n	%	n	%
Total	Yes	208	100	26	100	1 584 472	100
State	NSW	191	91.8	25	96.2	1 546 330	97.6
	ACT	17	8.2	<5		38 142	2.4
Maternal age	<35	111	53.4	20	76.9	1 218 173	76.9
	≥35	97	46.6	6	23.1	366 299	23.1
Private patient	Yes	56	26.9	11	42.3	429 016	27.1
Australia/New Zealand born	Yes	123	59.1	22	84.6	1 095 519	69.1
Socioeconomic status quintile <sup>12</sup>	1 Most disadvantaged	49	23.6	5	19.2	391 549	24.7
	2	35	16.8	6	23.1	350 715	22.1
	3	43	20.7	6	23.1	261 301	16.5
	4	21	10.1	<5		223 347	14.1
	5 Least disadvantaged	60	28.8	7	26.9	356 159	22.5
Smoke in pregnancy		23	11.1	<5		177 846	11.2
Primiparous		70	33.7	12	46.2	659 235	41.6
Previous CS		84	40.4	6	23.1	243 570	15.4
Antepartum hemorrhage		21	10.1	<5		46 828	3
Postpartum hemorrhage		150	72.1	23	88.5	152 865	9.6
Placenta previa		71	34.1	<5		17 585	1.1
Placenta accreta spectrum		81	38.9	<5		4 277	0.3
Bleeding disorder		31	14.9	<5		21 198	1.3
Gestational diabetes		31	14.9	<5		149 642	9.4
Pregnancy hypertension		30	14.4	8	30.8	138 533	8.7
Multiple birth		5	2.4	<5		24 171	1.5
Non-instrumental vaginal delivery		42	20.2	11	42.3	912 838	57.6
Cesarean section—no labor		116	55.8	5	19.2	294 407	18.6
Following labor		33	15.9	6	23.1	197 853	12.5
Instrumental delivery		19	9.1	5	19.2	183 523	11.6
Induction of labor		46	22.1	10	38.5	477 917	30.2
Small for gestational age (<10th centile)		17	8.2	<5		155 020	9.8
Large for gestational age (>90th centile)		21	10.1	<5		154 342	9.7
Gestational age	20–32	10	4.8	<5		25 826	1.6
	33–36	52	25	<5		82 111	5.2
	37+	146	70.2	21	80.8	1 476 535	93.2
Hospital of birth	Tertiary	119	57.2	8	30.8	535 634	33.8
	Other public	53	25.5	8	30.8	669 257	42.2
	Private	36	17.3	10	38.5	379 578	24
Hospital where IR performed	Tertiary	132	63.5	11	42.3		
	Other public	40	19.2	7	26.9		
	Private	34	16.3	8	30.8		
Region where IR performed	Urban	152	73.1	16	61.5		
	Rural/regional	21	10.1	<5			

Abbreviations: ACT, Australian Capital Territory; CS, cesarean section; IR, interventional radiology; NSW, New South Wales.

Outcome	IR in birth stay		IR postnatally		No IR	
	n	%	n	%	n	%
Total	208	100	26	100	1 584 472	100
Severe maternal morbidity	62	29.8	<5		11 776	0.7
Genitourinary tract trauma/repair	37	17.8	<5		26 692	1.7
Thrombosis/embolism	11	5.3	<5		1754	0.1
Hysterectomy at birth	59	28.4	<5		928	0.1
Hysterectomy within 12 months	62	29.8	<5		1145	0.1
Blood transfusion	138	66.3	20	76.9	24 799	1.6
Length of stay >5 days	129	62	5	19.2	114 122	7.2
Readmission (postnatal)	26	12.5	26	100	61 149	3.9
Readmission involving transfusion	<5		19	73.1	1198	0.1

TABLE 2 Unadjusted outcome rates for women who received and did not receive pelvic interventional radiology at birth or postnatally, in New South Wales and Australian Capital Territory, 2003–2019

Abbreviation: IR, interventional radiology.

with PAS who had IR together with a cesarean hysterectomy tended to be at lower risk of blood or blood product transfusion and higher risk of deep vein thrombosis/pulmonary embolism; however, their risk for other adverse outcomes was similar to matched controls.

Women who had IR in the birth admission were older, more likely to be multiparous and have a history of cesarean delivery compared with women who did not have IR. This may reflect the high rate of PAS among women undergoing IR, which is also strongly associated with those characteristics.<sup>16</sup> This is consistent with previous studies.<sup>4,17</sup> IR was more common among women born outside of Australia and New Zealand, and is likely related to the finding that the majority of procedures were performed at a small number of urban hospitals serving multicultural areas. Higher rates of gestational diabetes, preterm birth and hypertension in women undergoing IR have been reported previously.<sup>17</sup> The use of IR in women with a higher risk profile is reflected in the higher unadjusted rates of adverse outcomes seen in this study.

IR was performed at approximately 10% of public hospitals, with five hospitals responsible for the majority of procedures that occurred in NSW and the ACT. This likely reflects the availability of required expertise, the multidisciplinary approach and coordination necessary,<sup>6</sup> as well as the availability of suitable facilities. Interestingly, whereas the majority of IR procedures in the PAS subset occurred at tertiary hospitals, a substantial number of IR procedures overall occurred at non-tertiary public and private hospitals. The decision to use IR is likely highly dependent on clinician preference and experience.

This study found no evidence of improved outcomes, and little evidence of higher risk of adverse outcomes, for women undergoing IR in the context of planned cesarean with hysterectomy for PAS compared with similarly high-risk women. Some studies have found higher mean length of stay among women receiving IR for PAS management compared with alternative treatments, but the studies had

low sample sizes and the differences were not significant.<sup>18–20</sup> The higher rate of severe morbidity was driven by repair to the bladder, which may be related to the depth of placental invasion rather than being an outcome of the IR. Overall, our results support the view that there is little risk of excess harm posed by obstetric use of IR,<sup>1,4,9,17,21</sup> although we did not find evidence that it is effective at improving outcomes, aside from possibly reducing transfusion requirements. That said, to minimize bias by unmeasured confounding we selected a cohort who all had a hysterectomy, and we were therefore unable to determine whether IR reduced the need for hysterectomy. It is important to balance the risks and benefits, and manage them individually for each patient.

A strength of this study is the use of population-level data, collected over 17 years, in contrast to previous studies that have been limited to case studies, highly selected study groups or single institutions. This allowed for associations between this rare procedure and pregnancy characteristics and outcomes to be observed, and for longer-term outcomes within 12 months to be included. While much of the literature focuses on IR for PAS management, our inclusion of all women with pelvic IR during the birth and postpartum period provides a broad picture of how these procedures are used for women receiving obstetric care.

A limitation of this study is that we are unable to distinguish between the type of IR used for each patient, as the same procedure code applies to the use of balloon occlusion catheters, whether or not the catheter was inflated, and arterial embolization. As a result, it was not possible to determine whether IR was used prophylactically or in an emergency setting. Our subgroup analysis aimed to address this limitation by identifying prophylactic IR in women with PAS.

Other clinical information that may have been useful covariates for modeling risk of IR or adverse outcomes, such as volume of blood loss, antenatal diagnosis and severity of PAS, or indication for hysterectomy (planned or unplanned), was not available in the routinely

**TABLE 3** Maternal and pregnancy characteristics, before and after matching, of women with with placenta accreta spectrum who received interventional radiology and planned cesarean with hysterectomy compared with women who had placenta accreta spectrum and planned cesarean with hysterectomy who did not have interventional radiology, in New South Wales and Australian Capital Territory, 2003–2019

Characteristic	Code	Total		IR		No IR		P-value
		n	%	n	%	n	%	
Total		88	100	44	100	44	100	
Maternal age	<35	39	44.3	19	43.2	20	45.5	0.83
	≥35	49	55.7	25	56.8	24	54.5	
Private patient	Yes	23	26.1	11	25	12	27.3	0.81
Australian/New Zealand born	Yes	62	70.5	28	63.6	34	77.3	0.16
Socioeconomic status	1 Most disadvantaged	15	17	10	22.7	5	11.4	0.53
	2	21	23.9	8	18.2	13	29.5	
	3	15	17	7	15.9	8	18.2	
	4	13	14.8	6	13.6	7	15.9	
	5 Least disadvantaged	24	27.3	13	29.5	11	25	
Smoke	Yes	16	18.2	8	18.2	8	18.2	1
Previous CS	Yes	76	86.4	40	90.9	36	81.8	0.21
PPH	Yes	48	54.5	23	52.3	25	56.8	0.67
Placenta previa	Yes	64	72.7	32	72.7	32	72.7	1
Bleeding disorder	Yes	6	6.8					
Gestational diabetes	Yes	14	15.9	6	13.6	8	18.2	0.56
Pregnancy hypertension	Yes	9	10.2					0.29
LGA	Yes	12	13.6	5	11.4	7	15.9	0.53
Gestational age	20–32	14	15.9					0.06
	33–36	37	42	20	45.5	17	38.6	
	37+	37	42	21	47.7	16	36.4	
Hospital of birth	Tertiary	66	75	33	75	33	75	1
Hospital of IR	Tertiary	35	39.8	35	79.5			1

Abbreviations: CS, cesarean section; IR, interventional radiology; LGA, large for gestational age; PPH, postpartum hemorrhage.

**TABLE 4** Outcomes from propensity-matched sample for women with placenta accreta spectrum, planned cesarean with hysterectomy who received interventional radiology in the birth admission compared with those who did not, in New South Wales and Australian Capital Territory, 2003–2019

Outcome	Total		IR		No IR		p-value	aRR	95% CI
	n	%	n	%	n	%			
Total	88	100	44	100	44	100			
Severe maternal morbidity	26	29.5	17	38.6	9	20.5	0.06	1.9	0.8–4.2
Genitourinary tract trauma/repair	23	26.1	15	34.1	8	18.2	0.09	1.9	0.8–4.4
Thrombosis/embolism	<5		<5		0		0.08	–	
Blood transfusion	59	65.9	25	56.8	34	77.3	0.04	0.7	0.4–1.2
Length of stay >5 days	71	80.7	33	75	38	86.4	0.17	0.9	0.5–1.4
Readmission	–		5	11.4	<5		0.72	1.3	0.3–4.7

Abbreviations: aRR, adjusted risk ratio; IR, interventional radiology.

collected data. As such, there may be residual confounding by indication in the adjusted analysis, where a clinicians' decision to use IR was based on something not recorded in the patient's notes. This was mitigated as much as possible by matching on a range of factors. We were also unable to examine other outcomes of interest such as blood volume loss and number of units transfused. Although the current study is larger than most studies on the topic, the rarity of the procedure limited power to detect differences in rare outcomes (such as thromboembolism).

Finally, the lack of a specific procedure code for pelvic IR prior to 2008 means that some of the procedures identified may not have been pregnancy-related. However, the majority of IR procedure codes from 2008 onwards were for pelvic IR (196/228 86%) and therefore we expect that the procedures recorded under the pre-2008 code were predominantly for pelvic IR procedures.

## 5 | CONCLUSION

This study adds to the limited available evidence on the use of IR in pregnancy and postpartum. IR is rare among this patient group and is offered at a limited number of hospitals in NSW, largely at tertiary centers. Within a high-risk subset of women with PAS undergoing planned cesarean with hysterectomy, we found similar outcomes in those who did and did not receive IR, with some evidence of a reduced risk of bleeding for those receiving IR. This study supports the findings of previous research that IR is likely safe in pregnancy and postpartum.

### AUTHOR CONTRIBUTIONS

HJB performed the initial analysis and drafted the manuscript. DAR devised the study, reviewed the analysis and final paper. RM, SW and JMM provided clinical guidance on the planning of the study, interpretation of the findings and reviewed the paper. ST provided epidemiological oversight of the study, reviewed the methods and final paper. JAP devised the study, performed the analysis and reviewed the paper.

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### CONFLICT OF INTEREST

None.

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### ORCID

Deborah A. Randall  <https://orcid.org/0000-0002-5075-0227>

Jillian A. Patterson  <https://orcid.org/0000-0002-9888-9818>

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