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Travel distances from institutions designated to detain women and girls to procedural (surgical) abortion facilities in Australia: A geospatial analysis

Clare Heggie[a,*], Anna Noonan[b], Martha Paynter[c]

[a] University of New Brunswick Department of Interdisciplinary Studies, 3 Bailey Drive, P.O. Box 4400, Fredericton E3B 5A3, NB, Canada
[b] University of Sydney, Faculty of Medicine and Health, Anderson Stuart Building, The University of Sydney, Camperdown, NSW 2050, Australia
[c] University of New Brunswick Faculty of Nursing, 33 Dineen Dr, Fredericton E3B 5A3, NB, Canada

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ABSTRACT

Women are a fast growing population in prisons in Australia. The growing number of women in prisons challenges the ability of correctional services to meet gendered healthcare needs. People in prisons for women face a number of barriers accessing essential sexual and reproductive healthcare needs, including access to abortion. Distance is one potential barrier to accessing care. The purpose of this study was to create a directory of all institutions of incarceration designated to detain women or girls in Australia (including state-based correctional centres, youth detention centres, immigration detention centres, and secure forensic hospital); create a directory of all known procedural abortion facilities listed in state and territory-based abortion service directories and; measure the distance in kilometres and travel time between institutions of incarceration designated for women or girls and procedural abortion facilities. Among the 55 identified institutions designated to incarcerate women or girls, we identified distances between institutions of incarceration and procedural abortion services ranging from 0.4 to 2604 km, with the largest distances observed in Western Australia. The majority of institutions of incarceration were located between 20 and 100 km away from a procedural abortion facility. Despite decriminalization, the availability of procedural abortion varies greatly across Australia, and inequities may be exacerbated for people in state or youth correctional centres, immigration detention centres, and secure forensic hospitals or rehabilitation units. Distance represents just one barrier to accessing essential reproductive healthcare, and further research is needed to identify additional barriers and implications for health equity, reproductive justice and reproductive autonomy.

Introduction

Women are a fast growing prison population in Australia. While women remain a small proportion (7.6 %) of the overall prison population (ABS, 2024a), the population of people in female designated facilities increased by 65 % between 2000 and 2019, while the male prison population increased by 45 % (AIHW, 2020). This trend is not unique to Australia. In Canada, women represented 5.7 % of all federal admissions and 11 % of all provincial and territorial admissions to adult custody in 2006 (Landry & Sinha, 2008), and today represent 7 % of all federal admissions and 14 % of all provincial and territorial admissions (Public Safety Canada, 2024; Statistics Canada, 2024). In the United States, the rate of incarceration of women in both state prisons and county jails has grown at twice the pace of the male population since 1978 (Sawyer, 2018). Globally, the population of women in prison has grown 33 % from 2000 to 2019 (UNODC, 2021). This national and global trend elevates the need for appropriate and comprehensive health care policies and services that accommodate the specific sexual and reproductive healthcare needs of people in prisons designated for women, including access to abortion care (Breuer et al., 2021). Yet, little is known about the provision of sexual and reproductive health care in prisons in Australia.

A 2023 international scoping review on abortion and contraception access in prisons identified several barriers to access, including limited onsite reproductive health care, stigma and coercion by healthcare professionals, out-of-pocket costs, and disruptions to insurance coverage while incarcerated (Paynter et al., 2023). The majority of identified studies were conducted in the USA. While there were no studies from Australia included in the review, the two studies conducted in Canada may offer important contextual and comparative information for the

* Corresponding author.
E-mail address: clare.heggie@unb.ca (C. Heggie).

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Australian context given abortion provision is now decriminalized in both countries. In a 2014 survey of 85 women in a Canadian provincial correctional facility, Liauw et al. (2016) identified both high lifetime rates of abortion and unmet need for contraception: 57 % of participants who had ever been pregnant had prior abortion, and 80 % of participants who were at risk for unintended pregnancy were not using reliable contraception prior to admission to the correctional facility. In a follow-up qualitative study, Liauw et al. (2021) found that participants faced institutional barriers and delays accessing essential reproductive healthcare, including abortion services. In a qualitative study of the experiences of women and gender diverse people who had previously been provincially or federally incarcerated in Canada seeking abortion and contraception care, Paynter et al. (In press) found participants experienced contraceptive denial and coercion, faced challenges accessing evidence-based and appropriate reproductive health information, and felt forced to prioritize emergent health needs such as substance use withdrawal and acute mental illness over their reproductive health concerns in order to receive essential care. In a cross-sectional survey of sexual and reproductive health status among people incarcerated in four provincial prisons for women in Canada, Paynter et al. (Forthcoming) found that 51 % of participants had ever had an abortion, and the median number of lifetime abortions per person was 1.6. A 2024 systematic review of women's subjective experiences accessing abortion care while incarcerated reported that incarcerated women faced bureaucratic barriers, confidentiality violations and stigma in attempting to access abortion (Murray et al., 2024). This review also did not identify any Australian studies.

After decades of campaigning, decriminalization of abortion was achieved through separate legal reform processes in each of Australia's states and territories, culminating in full decriminalization in 2021 (Millar & Baird, 2021). Yet despite decriminalization and an otherwise universal health insurance model (Medicare), abortion in Australia is not publicly funded or routinely available in public hospitals. Furthermore, in Australia, restrictions to set limits on maximum gestational duration and regulations governing which health professionals can provide/prescribe abortion care differ between states and territories, and conscientious objection can contribute to stigma and delays accessing care (Keogh, Gillam, et al., 2019; Millar, 2023). Like in Canada and New Zealand, abortion is not routinely taught in health professional training (Macfarlane & Paterson, 2020; Myran et al., 2018). Low numbers of abortion providers/prescribers in primary care, sparse and inconsistent availability in public hospitals, widespread community and professional stigma, and conscientious objection to abortion constrain access to abortion in Australia. For those who live outside major city centres, additional access barriers include distance, cost and time required to travel to services, and opaque and fragmented pathways to care (Makleff et al., 2023; Noonan et al., 2023a,b; Sifris & Penovic, 2021).

Medication abortion (or early medical abortion as it is most commonly known in Australia) became readily available in Australia in 2012 when MS Health, an Australia-based pharmaceutical company successfully applied to the Therapeutic Goods Administration (TGA) to gain approval for MS 2 Step, its pharmaceutical product 'combi-pack' containing the two drugs mifepristone and misoprostol medication to be sold in Australia (Dawson et al., 2017). Prior to August 2023 when the TGA expanded the prescribing workforce to include nurses and midwives, physicians were the only healthcare professionals permitted to prescribe MS 2 Step provided they had completed a free online 3–4 h training program administered by MS Health and registered (Bateson et al., 2021). MS 2 Step is approved for use to 9 weeks gestational duration (TGA, 2022).

Despite the availability of MS 2 Step in Australia for over a decade, and the recent relaxing of training requirements by Australia's pharmaceutical regulatory body in 2023, only 11 % of GPs are self-reported to be providing this service to their communities (Srinivasan et al., 2024). Conscientious objection and beliefs that abortion should not be part of the GP scope of practice were cited in two separate studies as barriers inhibiting greater uptake of medication abortion among Australia's GP population in a qualitative study of general practitioners in New South Wales (Dawson et al., 2017) and a survey of general practitioners in Victoria (Keogh, Croy, et al., 2019). Currently abortion services – both medication (medical) and procedural (surgical) - are still mostly provided by healthcare professionals working in a small number of non-government and private clinics, most of which are located in major cities (Noonan et al., 2023a). Medication abortion via telehealth is available for individuals who live within 2 h of 24/h emergency medical care (MSI Health, 2024), but it is yet unclear whether this has improved access to abortion for people living in rural, remote, or under-serviced areas (Seymour et al., 2024).

It is estimated that one in four women in Australia will seek or obtain an abortion in their reproductive lifetime (Melville, 2022). However, currently there is no national routinely collected data about the provision of abortion services nation-wide. It is therefore not surprising that data with respect to abortion in prison settings is not available. A 2009 survey conducted in both prisons designated for men and for women in two states in Australia reported 46.9 % of female respondents had experienced an abortion, but it was unclear whether this occurred during a period of incarceration (Butler et al., 2013). From 2021 to 2022, data collected by the Australia Bureau of Statistics identified that 72 % of female prison entrants had ever been pregnant, and 7 % were currently pregnant (AIHW, 2023).

Health service delivery for prison populations in Australia is the responsibility of each state and territory. Despite national and international standards mandating the state ensure health services in prisons are equal to what is available in the community (AIHW, 2009; RACCGP, 2023; UNODC, 2010, 2015), Australian research on healthcare access during and immediately after release from prison has found incarcerated people face long wait times, experience challenges both navigating custodial health care systems and connecting with health care upon release, and report receiving inferior quality healthcare while in custody (Abbott et al., 2016; Kinner et al., 2012; Lloyd et al., 2015; Wolf & Bagaric, 2024). Aboriginal and Torres Strait Islander women are over-represented in the Australian prison system, representing 41 % of all women in prison in Australia (ABS, 2024a) while making up only 3.8 % of the population of women in Australia (AIHW, 2023), and may experience discrimination, medical racism, and a lack of appropriate, equitable and culturally safe health care services (Kendall et al., 2019; Kendall et al., 2020; Sullivan et al., 2019).

Travel distance to the nearest available service is one of the main logistical barriers to abortion in Australia (Doran & Hornibrook, 2014; Nickson et al., 2006). This may be exacerbated for incarcerated people who rely on corrections officials to approve and arrange both appointments and the necessary travel. Prior studies in the United States (Gips et al., 2020) and Canada (Paynter & Heggie, 2023) measured distance between prisons designated to incarcerated women and procedural abortion facilities in order to explicate if and how distance to care may create barriers to abortion access for people in prisons. Paynter and Heggie focused on procedural abortion over medication abortion because of the potential clinical inappropriateness of medication abortion in the prison setting, where prisoners lack privacy, emergency care for complications, access to over-the-counter pain and nausea medication, ample supply of menstrual hygiene products, and showers (Paynter & Heggie, 2023).

The purpose of this study was to 1) Create a directory of all institutions of incarceration designated to detain women or girls in Australia (including state-based correctional centres, youth detention centres, immigration detention centres, and secure forensic hospitals) 2) Create a directory of all known procedural abortion facilities listed in state and territory-based abortion service directories, and 3) Measure the distance in kilometres and travel time between institutions of incarceration designated for women or girls and procedural abortion facilities.

Methods

Data collection

We created a directory of all institutions of incarceration designated for women and girls in Australia through an environmental scan of publicly available information on the Corrective Services department websites in each Australia state and territory, and the Australia Border Force. We identified and collected data for four types of institutions: state-based correctional centres, youth detention centres, immigration detention centres, and secure forensic hospitals. For each institution, we recorded the state/territory, phone number, street address and co-ordinates (longitude and latitude), security level(s), whether or not the facility/unit designated for women was co-located with a facility/unit designated for men, total capacity, capacity for women/girls, whether the facility operated on a public or private basis, the department responsible for delivery of health services, and if the facility has a residential mother-child program. In cases where two facilities are located on the same campus, they were counted as two facilities, such as Alice Spring Youth Detention Centre and Alice Springs Female Correctional Centre in Northern Territory. We did not include police lock-ups or involuntary mental health units in non-secure hospitals.

We identified procedural abortion facilities through an environmental scan of publicly available online directories from each state and territory where available, and from publicly available online directories maintained by Children by Choice, 1800 My Options, and Marie Stopes International (MSI) Australia. Children by Choice is an independent non-profit organization providing informational and counselling support for all pregnancy options in Queensland (Children by Choice, 2024). 1800 My Options is a phone line and online platform providing information about contraception and pregnancy options in Victoria, run by Women's Health Victoria (1800 My Options, 2024). MSI Australia is a national non-profit organization providing abortion, contraception and vasectomy services (MSI Reproductive Choices, 2024).

For each procedural abortion facility, we recorded the clinic name, street address and coordinates (longitude and latitude), type of facility (private clinic, private hospital, public clinic, public hospital, not-for-profit or charity, hybrid), the maximum gestational duration to access care in weeks, out of pocket cost of procedure, and other relevant notes as available, such as if physician referral is required and if priority access is given to specific populations. We validated the list of procedural abortion facilities iteratively by sharing the directory with our networks including regional abortion providers/prescribers and national stakeholders in abortion care, updating the list as suggested, and re-sharing the list until consensus was reached. The search process started in March 2024 and validation was completed in June 2024.

Analysis

We used OpenStreetMap data and the Open Source Routing Machine (OSRM) to calculate minimum travel distances between the institutions of incarceration and procedural abortion facilities. For each institution of incarceration, we recorded the nearest facility, the minimum travel distance in kilometres, and the average travel time in minutes. To visualize the geographic spread of all institutions of incarceration and procedural abortion facilities, we created a Google Map. The information extracted for each institution and facility is visible by clicking on the representative icon. See Fig. 1. Interactive map is available at the following link: https://www.google.com/maps/d/u/0/edit?mid=1V2LGX6Ve1rfxTqIbVAfNBbYl_MHNPdI&usp=sharing

Results

Institutions of incarceration

We identified a total of 55 institutions designated for women and

Fig. 1.. Prisons Designated for Women and Girls in Australia and Distance to Procedural Abortion Services.

girls: thirty-three (33) state-based correctional centres, 11 youth detention centres, 7 immigration detention centres, and 4 secure forensic hospitals/rehabilitation units. The province of New South Wales had the highest number of total institutions, at 16. There were 12 in Western Australia; 8 in Queensland; 5 in South Australia, 4 each in Tasmania, Northern Territory, and Victoria; and 2 in Australian Capital Territory.

Of the 33 state correctional centres, 16 were co-located with men, and only 18 reported their capacity for women. Capacities for women ranged from 11 (Parramatta Transitional Centre in New South Wales) to 604 (Dame Phyllis Frost Centre in Victoria). All but one institution (Melaleuca Women's Prison in Western Australia, operated by Sodexo) was publicly operated. Healthcare is managed and provided by the state health system in all but two states; in Western Australia and Victoria, care is managed and delivered by the Justice Department. Seventeen facilities publicly listed information about mother-child programs.

Among the eleven youth detention centres, all were co-located with boys and none reported specific capacity for girls. Overall capacities ranged from 18 (Alice Springs Youth Detention Centre in Tasmania) to 162 (Brisbane Youth Detention Centre). All were publicly managed. Two facilities (Ashley Youth Detention Centre in Tasmania and Don Dale Youth Detention Centre in Northern Territory) are slated for closure. Ashley Youth Detention Centre is slated for closure by 2026; Don Dale Youth Detention Centre was slated for closure in 2018, but is still detaining youth as of 2024 (Morgan, 2024). Availability of residential mother-child programs in the youth facilities is unknown.

Among the four secure forensic hospitals designated for women, three were co-located with men. None of these reported specific capacity for women. The one facility designated for women only, Miruma, the rehabilitation unit in New South Wales, has capacity for 11. Availability of residential mother-child programs in the youth facilities is unknown.

Among the seven immigration detention centres (IDC), all were co-located with men. None reported specific capacity for women; overall capacities range from 25 (Adelaide IDC in South Australia) to 432 (Villawood IDC in New South Wales). All IDCs are privately managed by SERCO. SERCO delivers healthcare through International Health and Medical Services, a subsidiary of the private health and security firm International SOS (Australian National Audit Office, 2016). All seven IDCs allow mothers and babies to stay together.

Procedural abortion facilities

We identified a total of 69 abortion facilities. The highest number were in New South Wales and Victoria, with 19 each (0.2 per 100,000 adult population in New South Wales and 0.3 per 100,000 adult population in Victoria), followed by 9 in Queensland, 7 in South Australia, 5 each in Western Australia and Northern Territory population, 3 in Tasmania, and 2 in Australian Capital Territory. The facilities included 33 private clinics, 29 public hospitals, and 7 public clinics. Fees for private services were often not listed; of those listed, fees ranged from $600–$1700. Gestational duration limitations were usually not listed; of the facilities that did list them, the maximums ranged from 9 to 24 weeks.

Distance analysis results

Of the 49 institutions of incarceration, 16 (29.1 %) were located 0 to 10 km from a procedural abortion facility. Ten (18.2 %) were located 10.1 to 20 km away. Seventeen (30.9 %) were located 20.1 to 100 km away. Three (5.5 %) were located 100–1 to 300 away, and four (7.3 %) 300.1 to 500 km away. The remaining 5 (9.1 %) institutions of incarceration were located 500.1 km or greater away from a procedural abortion facility, to a maximum of 2604 km.

Among the 33 state correctional centres, distances varied from 0.41 to 1557 km, with a range in driving time from 1 min to 27 h. The median distance from a state correctional centre to a procedural abortion facility was 217 km. Among the five youth detention centres, distances varied from 9 to 347 km, with a range in driving time from 12 to 283 min, or over 4 h. The median distance from a youth detention centre to a procedural abortion facility was 69 km. Among the four secure forensic hospitals/rehabilitation units, distances ranged from 6 to 47 km, with a range in driving time from 10 to 52 min. The median distance from a secure hospital to a procedural abortion facility was 19 km.

Among the seven immigration detention centres (IDC), distances ranged from 6 to 2604 km by air. The median distance from an IDC to a procedural abortion facility is 388 km. Driving travel times ranged from 5 to 60 min. In one case, travel would require a flight: the immigration detention centre reported the farthest distance to a procedural abortion facility, North West Point Immigration Detention Centre, is located off the coast of Mainland Australia on Christmas Island and is approximately a four hour flight from the nearest procedural abortion facility in Perth. Since August 2023, no one has been detained at North West Point IDC (Australian Border Force, 2023), and the facility remains open only as a 'contingency facility' (Karp, 2023). If we were to exclude North West Point IDC, the median distance among the remaining six IDCs to a procedural abortion facility is 19 km.

We found the greatest range in distances between institutions of incarceration and procedural abortion facilities in the state of Western Australia, where the range was 6 to 2604 km. Even when excluding the North West Point IDC, located in Western Australia, the state was still found to have the largest range in distance, from 6 to 1557 km. Roeburn Regional Prison, West Kimberley Regional Prison, and Broome Regional Prison, all in Western Australia, are all located more than 1000 km from the nearest procedural abortion facility. The nearest facility for both Broome Regional Prison and West Kimberley Regional Prison is a hospital out of state in Northern Territory. If required to access care in-state, the nearest procedural abortion facilities would be 2206 and 2352 km away, respectively. Although remote institutions of incarceration may have a relatively close community hospital or health clinic, patients may need to be transferred to a major centre to access care. For example, Townsville Correctional Centre in Queensland is 360 km away from a sexual health clinic, where medication and/or procedural abortion is available to 13 weeks, but would need to travel 1343 km to Brisbane to receive care after 13 weeks, and require a flight. Some private clinics may require physician referral to access care. The need for flight arrangements and/or additional physician approvals creates additional barriers for abortion-seekers, particularly those in prisons.

The distribution of institutions of incarceration, procedural abortion facilities, and distances between them by state and territory is summarized in Table 1.

Discussion

This exploratory study aimed to measure distances between institutions of incarceration designated for women and girls and procedural abortion facilities in Australia. Distances ranged from less than one km to over 1000 km, with driving times ranging from several minutes to 20+ hours, requiring travel by air. This is a much larger range than those reported in similar studies in Canada and the USA; with the maximum distance reported in Canada as 738 km and the maximum distance reported in the USA as 616 km (Gips et al., 2020; Paynter et al., 2023). This current study identified 69 procedural abortion facilities in Australia as of June 2024, approximately 0.2 facilities per 100,000 population. The rate of facilities per 100,000 population is consistent with both Canadian and American studies: Paynter and Heggie (2023) identified 92 procedural abortion facilities and Gips et al. (2020) identified 643; both representing 0.2 procedural abortion facilities per 100,000 population.

Our findings are consistent with literature identifying the uneven availability of both procedural and medication abortion across Australia, resulting in 'abortion deserts' (Edvardsson et al., 2024; Noonan et al., 2023a,b; Parliament of Australia, 2023). Using Cartwright et al. (2018) definition of abortion deserts as places where patients are required to travel over 160 km to access care, 12 (35.3 %) of institutions

Table 1
Distribution of institutions of incarceration, procedural abortion facilities, and distances in Australia.

State/ territory	Number of correctional institutions (all types)	Correctional institutions per 100,000 populations	Number of procedural abortion facilities	Procedural abortion facilities per 100,000 population	Closest distance from correctional institution to abortion facility (km)	Farthest distance from correctional institution to closest abortion facility (km)	Maximum gestational duration capacity for care in state/ territory	Is procedural abortion publicly funded in this state/territory?
NSW	16	0.2	19	0.3	0.4089	325.8	22	No
VIC	4	0.06	19	0.3	5.7	41.3	24	No
QLD	8	0.1	9	0.2	2.9	360.2	22	No
WA	12	0.4	5	0.2	5.7	2604	23	No
SA	5	0.3	7	0.4	7.9	187.7	22 + 6 days	Yes
TAS	4	0.7	3	0.5	2.3	45.3	16	Yes
ACT	2	0.4	2	0.4	9.0	9.0	16	Yes
NT	4	1.6	5	2.0	8.7	22.1	24	Yes

of incarceration designated for women in Australia could be considered as abortion deserts based on distance to care alone. Institutions of incarceration that are less than 160 km to care may still function as abortion deserts due to limited reproductive health care on site, unclear access pathways, and a lack of proactive policy. Further research is needed on the experience and process of accessing abortion while incarcerated in Australia to understand how distance interacts with other potential barriers.

We found the farthest distances to care among institutions of incarceration in Western Australia. Despite being the fourth largest state by population after Victoria, Queensland, and New South Wales, Western Australia reported the second highest number of institutions of incarceration (ABS, 2023). Western Australia has disproportionately high rates of incarceration, incarcerating 322.3 persons per 100,000 adult population, compared to the national average of 203 persons per 100,000 adult population (ABS, 2024b). The incarceration rate of Aboriginal and Torres Strait Islanders in Western Australia is extremely disproportionate, incarcerating 4321.9 Aboriginal and Torres Strait Islander persons per 100,000 adult population. This is almost double the already disproportionately high national rate of 2591 Aboriginal and Torres Strait Islander persons per 100,000 adult population (ABS, 2024b). The hyper-incarceration of Aboriginal and Torres Strait Islander people in Western Australia, coupled with long distances to care from remote prisons, has implications for equitable sexual and reproductive care access.

There is no publicly available information on policies governing abortion access in state correctional centres, youth detention centres, immigration detention centres or secure forensic hospitals in Australia. Policies on access pathways may help to contextualize distances to care by identifying procedures for travel for out of state care and care in private clinics. There is also little publicly available information on medical transport policies and procedures. A 2023 report from the Western Australia Office of the Inspector of Custodial Services on the inter-prison transport of regional and remote prisoners in Western Australia identified inconsistencies with respect to toilet breaks, welfare checks and the use of restraints (OICS, 2023). A 2022 report from the New South Wales Inspector of Custodial Services on inter-prison, court and medical transport stated that toilet breaks are only required for journeys longer than 3 h, and that this policy may be followed inconsistently (ICS, 2022). Given the potentially lengthy distances to care, there is an urgent need for analysis of the policies for medical transport among institutions of incarceration designated for women and girls.

Limitations

There are several limitations to this study. Because there was no national directory of procedural abortion facilities in Australia, we created one through a systematic environmental scan, and in so doing encountered several challenges. Several facilities listed on state or organization directories did not mention any procedural abortion services on their website, and thus were not included in this analysis. Directories may also be missing facilities. We excluded medication abortion providers/prescribers based on the likely inappropriateness of medication abortion in the prison environment and the difficulty in identifying primary care physicians and nurse practitioners that may be prescribing medication abortion. Although we aimed to iteratively validate and update the list of facilities, it may not represent a comprehensive directory of all places to access procedural abortion in Australia. It is likely to reflect what a patient seeking care would be able to find through publicly available searching. As a result of the potential gaps in our directory of procedural abortion facilities, calculated median distances to care may also lack accuracy. The search and validation process was ended in June 2024, and there are likely advances in service since then. The intention was not to create a comprehensive or patient-facing directory of all services, but rather to generate estimates of distances from institutions of incarceration to procedural abortion providers and facilities.

Conclusion

Despite national decriminalization, the availability of procedural abortion varies greatly across Australia. A lack of both consistent public funding and routine provision in public hospitals results in vast inequities in access that may be felt more acutely for people living in rural or remote areas. These inequities may be exacerbated for people in state or youth correctional centres, immigration detention centres, and secure forensic hospitals or rehabilitation units. Distance represents just one barrier to accessing essential reproductive healthcare, and little is known about the policies at institutions of incarceration governing access to abortion, if there are any. Stigma, misinformation, risk of reproductive coercion, medical transport procedures, and other factors may present further barriers to abortion access for incarcerated people. Future research should explore these factors, their interaction with distance to care, and the implications for health equity, reproductive justice and reproductive autonomy.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable.

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CRediT authorship contribution statement

Clare Heggie: Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Anna Noonan:** Writing – review

& editing, Writing – original draft, Validation, Formal analysis, Data curation. **Martha Paynter:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no competing interests.

Data availability

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wsif.2024.103019.

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