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Prison cell spatial density and infectious and communicable diseases: a systematic review

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Prison cell spatial density and infectious and communicable diseases: a systematic review

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Prison cell spatial density and infectious and communicable diseases: a systematic review

Objective: To summarise the extent and quality of evidence on the association between prison cell spatial density (a measure of crowding) and infectious and communicable diseases transmission.

Design: Systematic review.

Data sources: Embase, PubMed, Medline, Scopus, Web of Science, PsycInfo, PsycExtra, Proquest Databases, Proquest Dissertations and Theses Global, Index to Legal Periodicals, Informit Online, Cochrane Library, Criminal Justice Abstracts and ICONDA.

Study selection: Studies that reported on the association between prison cell spatial density (measured in square feet or square metres of cell floor area per person) and infectious and communicable diseases in juvenile and adult populations incarcerated in a correctional facility.

Review methods: A review protocol was developed in consultation with an advisory panel. Two reviewers independently extracted data and used the Australian National Health and Medical Research Council's (NHMRC) checklist to critically appraise individual studies. An assessment of the overall body of the evidence was conducted using the NHMRC's Evidence Scale and Statement Form. A draft report was peer-reviewed by an independent researcher.

Findings: A total of 3,532 articles were initially identified with six included in the review from the United States (1980s), Pakistan (2003) and Nigeria (2012, 2013). Infectious and communicable disease outcomes included pneumococcal disease/acute pneumonia, mycobacterium tuberculosis, infectious skin conditions, and contagious disease reporting to the prison clinic. Five articles reported statistically significant associations but were countered by associations possibly being explained by chance, bias or confounding factors. Heterogeneity prevented meta-analysis.

Conclusion: Overall, the body of evidence provides some support for an association, but care should be taken in the interpretation and transferability of the findings. Future research and policy responses should adequately consider prospective mediating factors implicated in associations between cell spatial density and health effects.

Key words: Communicable Diseases; Infectious Diseases; Prisons; Prisoners; Crowding; Spatial Density

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Strengths and limitations of this study

- This is the first systematic review of prison cell spatial density (a measure of crowding) and infectious and communicable diseases.
- This review provides some evidence of an association between prison cell spatial density and infectious and communicable diseases but the quality of the studies was assessed as poor.
- The findings of the review indicate that future research and policy responses should adequately consider prospective mediating factors implicated in associations between cell spatial density and health effects.
- This review was limited by the small number of studies and the heterogeneity of study design.

Introduction

Globally, the number of prisoners is increasing. Two percent above world population growth,¹ since the year 2000 the world's prisoner population has grown by approximately 20%, imposing a significant financial burden on society and having profound social and health consequences.² More than 11 million people are held in penal institutions globally, either as remand (pre-trial detainees) or convicted prisoners. Currently, seventeen countries in the world have an incarceration rate of more than 400 per 100,000 population in prison. The United States (US) is the largest incarcerator, accounting for approximately 25% of the world's prisoners with an incarceration rate of 698 per 100,000 population.³

A rising prison population without a corresponding expansion of infrastructure has raised health concerns in many countries over prison crowding,³ making prison cell size a key public health issue. For example, in the Australian state of New South Wales (NSW), prison cell size as a public health issue emerged in recent times with the publication of the Inspector of Custodial Services' report Full House: the growth of the inmate population in NSW, the increase in the prisoner population, and the issue that a significant number of prison cells did not meet public health regulations on the minimum floor area requirements per prisoner. Historically, Corrective Services NSW had been exempted from such regulation provided a range of conditions imposed by the NSW Ministry of Health were met. In 2012, the Ministry required the NSW Department of Justice, Corrective Services to engage an independent [from Corrective Services] group to review the international literature on prison cell crowding and adverse health effects, a review of the international cell size guidelines, and a review of health surveillance data to advise the Ministers for Health and Justice.

Close physical proximity in confined spaces such as in prisons has been reported to be associated with an increased risk of infectious and communicable disease transmission including, mycobacterium tuberculosis, scabies, pneumococcus, meningococcus and

influenza.⁵⁻⁷ Rates of infectious diseases in prisons, particularly blood-borne viral infections (HIV and viral hepatitis) and airborne infections such as mycobacterium tuberculosis are typically higher than in the general community which exacerbates the risk of disease transmission.^{6,8,9} Additionally, it has been suggested that the close physical proximity in prisons may induce psychological stress or intensify the existing stressful conditions in a prison^{10,11} leading to alterations in immune and cardiovascular functions.¹²

The concept of crowding is understood in the academic literature and legislation as a mechanism that impacts adversely on the health and well-being of prisoners. Reports on prison conditions, prison standards and guidelines by international and regional agencies cite prison crowding as major health and human rights concerns impacting on this population.¹³⁻¹⁷ Left untreated in prison, the risk of disease transmission to family, friends, intimate partners, and other community members is likely upon leaving prison and returning to general society.¹⁸⁻²²

Despite decades of research dedicated to prison conditions and its impact on health, there has been no systematic review to assess the quality of evidence of the association between prison crowding and infectious and communicable disease transmission. A lack of consensus exists on the best way to conceptualise and measure the essential element(s) of crowding with the debate centring on the need for objective versus subjective measurements of crowding.^{23,24} The latter focuses on the individual experience or perception of crowding using subjective ratings of conditions such as behavioural constraints, stimulus and cognitive overload, privacy, desire to augment space, and loss of environmental control.^{12,25,26} The former, objective measures of prison crowding vary, but commonly revolve around metrics of prisoners per allocation of space to derive a measure of density (Table 1).

(Insert Table 1 here)

Some of these measures have been criticised as being amenable to manipulation by prison authorities and thus regarded as invalid measures of prison crowding.^{27,24} Measures iv.

to x. (Table 1) are regarded as objective measures of social and spatial density. *Social density* refers to the number of people in a defined area of the prison (e.g. the whole facility, wing, dormitory, or cell). *Spatial density* refers to the floor area of a defined area (e.g. entire prison or cell) divided by the number of people in that space¹¹. Social and spatial densities are often dependent on one another, such as when the cell occupancy level increases, this causes a corresponding increase in both social density and spatial density. In this review, the area (measured in square feet or square metres) of the cell per person was selected as the cell crowding measure and is referred to as *cell spatial density*. This measure was adopted for two reasons. Firstly, the lack of consensus in the academic literature on the conceptualisation and measurement of crowding impressed the need to define cell crowding as an objectively defined environmental factor. Secondly, an examination of international guidelines on prison conditions and standards over the last half a century has seen a shift towards standards based on cell spatial density (see Simpson, Simpson and Butler, 2016). Cell spatial density as a metric has also entered the legislative domain such as in the Australian Capital Territory's *Human Rights Act 2004* which recommends 8.9m² for single cells and 10.7m² for double cells.¹⁶

To determine the extent and quality of evidence on the association between prison cell crowding and health impacts, we were engaged by the New South Wales Department of Justice, Correctives Services to conduct a systematic review of studies that analysed the association between prison cell spatial density and prisoner infectious and communicable diseases and mental health and well-being outcomes. In this paper we present the results of our review of the association between cell spatial density and prisoner infectious and communicable disease effects, expressed in terms of the evidence of this association and the quality of the evidence.

Methods

Under the direction of the NSW Ministry of Health and the NSW Department of Justice, an expert advisory panel was formed to guide the review comprising infectious diseases experts,

public health professionals, academic staff and custodial administrators. A review protocol was developed following consultations with the advisory panel covering search strategy and selection criteria and study eligibility and appraisal. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Guidelines was adopted for the review.²⁸

Search strategy and selection criteria

A search string was agreed to identify articles on the association between cell spatial density and infectious and communicable diseases and mental health outcomes (Table 2). For the present paper, articles reporting on infectious and communicable disease outcomes were extracted from the final list of eligible studies. Review of the mental health outcome studies are reported elsewhere.²⁹ Infectious and communicable diseases are defined ‘as an illness due to a specific infectious agent or its toxic products that arises through transmission of such agent or products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or inanimate environment’.⁵⁰

The scope of the search was limited to the availability of an English abstract and to human subjects. Publication date was not restricted. Studies were excluded if they examined only temporary accommodation within custodial settings such as segregation cells, police cells, lockups, prison transport/transfer units, and prison clinic accommodation. Studies examining combined living and sleeping space preventing the differentiation of sleeping space were also excluded from the current review.

Fourteen medical, social science and architectural databases were searched: EMBASE (1947-2015), PubMed (≈1800-2015), Medline (1946-2015), Scopus (1976-2015), PsycInfo (1806-2015), PsycExtra (1908-2015), Web of Science (1900-2015), Proquest Databases (1763-2015), Proquest Dissertations and Theses Global (1716-2015), Index to Legal Periodicals (1985-2015), Informit Online (1920-2015), Cochrane Library (≈1900-2015), Criminal Justice

Abstracts (1910-2015) and ICONDA (1976-2015). Grey literature was also identified from these database searches; and a further search for grey literature was conducted using Google and selected websites including those of the United Nations, International Committee of the Red Cross, Amnesty International, International Centre for Prison Studies, World Health Organization, Campbell Collaboration, the Criminal Justice Reference Service, the United States' (US) National Library of Medicine and websites of the Australian Inspector of Custodial Services. A number of international experts in the prisoner health area were contacted to inquire as to whether they were aware of additional material of potential interest to the review.

To manage records identified, articles were exported from databases into EndNote X7.1. Grey literature from non-database sources were entered into Endnote manually. PDF versions of articles were located and attached to Endnote items.

(Insert Table 2 here)

Study eligibility

Articles were included if the study design featured in the Australian National Health and Medical Research Council's (NHMRC) Hierarchy of Evidence.³⁰ This includes systematic reviews of prospective cohort studies (level I evidence), prospective cohort study (level II evidence), 'all or none' study (i.e. either all or none of the people with the risk factor(s) experienced the outcome of interest) (level III-1 evidence) retrospective cohort study (level III-2 evidence), case-control study (level III-3 evidence), or cross-sectional study or case series (level IV evidence).³⁰

All publications identified by the search were screened by two independent teams of two reviewers (PS, AA, and MS, LY). To ensure consistency in the screening process and selection of eligible studies across the teams, the first 100 studies were independently reviewed by both teams using a data extraction template and the results of the review discussed as a

group to ensure consistency. After achieving a consensus on eligibility for inclusion across both teams, the remaining articles were divided between the two teams of reviewers. Each person within the team independently reviewed their assigned literature, and upon finishing, discussed the review outcome with the other team member. In those instances where there was disagreement within a team, both teams met to resolve the issues.

Critical appraisal of eligible studies

Critical appraisal of eligible studies involved three stages: (i) data extraction,³¹ (ii) assessment of bias, chance and confounding,³² and (iii) an aggregated assessment of all studies using a modified NHMRC Evidence Scale and Statement Form to produce a final rating and evidence statement.³⁰

An adapted version of the NHMRC’s standardised data summary table was used to extract data.³¹ Data extraction tables were prepared and cross-checked by two independent reviewers (PS, MS). Extracted information included: general study details (citation, study design, length of follow-up, level of evidence, and location and setting); study exposure and control descriptions; population characteristics; internal and external validity considerations; and study outcomes and results.

Assessment of bias, chance and confounding was guided by the NHMRC’s checklist to critically appraise aetiology or risk factor studies.³² Checklist items used to guide the assessment of studies included: exposure misclassification; outcome misclassification; selection bias; confounding; and chance. Items were assessed on one of two 3-point scales: low (0), medium (1), high (2) risk; or poor (0), fair (1), good (2).

A systematic assessment of the overall body of the evidence was conducted using a modified (for study population relevance) NHMRC’s Evidence Rating and Statement Form covering:³⁰ 1) evidence base; 2) consistency of results; 3) population health impact; and 4) generalisability. Each component was rated from Excellent to Poor (Appendix A) to allow a

final overall rating and evidence statement to be derived ranging from 'A' to 'D': 'A' indicating that the body of evidence can be trusted to 'D' indicating that the body of evidence is weak, and findings cannot be trusted. (Appendix B).³⁰ The final overall rating and evidence statement were undertaken by one reviewer (PS) and cross-checked by another (MS).

Following the completion of the review by the team, an expert, independent of the reviewers and advisory panel, peer reviewed the methodology and findings.

Patient and public involvement

Patients and the public were not involved in the review.

Findings

After removing duplicate records and newspaper and magazine articles, a total of 3,532 records were assessed for eligibility based on publication title and abstract content (Figure 1). As a result of this screening, 26 peer-reviewed and 10 items of grey literature that reported on infectious and communicable diseases and/or mental health outcomes were identified for final assessment for eligibility. For the present review, six publications met the inclusion criteria for infectious and communicable disease outcomes; four articles were published in peer-reviewed journals³³⁻³⁶ and two were reports.^{27,37} Two articles related to the same research program on prison crowding;^{27,37} two articles derived from the same study on infectious skin conditions.^{35,36} Four articles examined the association between cell spatial density and pneumococcal disease or acute pneumonia,³³ mycobacterium tuberculosis (MTB),³⁴ and infectious skin conditions,^{35,36} respectively, while two articles reported on communicable illness presentation to the prison clinic.^{27,37} Three studies were conducted in the United States of America (US),^{27,33,37} two in Nigeria^{35,36} and one in Pakistan (Table 3).³⁴ Meta-analysis was not possible due to heterogeneity and incomplete reporting of findings.

Five studies were cross-sectional in design (level IV aetiology evidence) and one included both a case-control and cohort study design reported in the same article (level III-

3/III-2 aetiology evidence). Outcome measures for the pneumococcal disease³³ and MTB³⁴ studies were measured using a standardised and reliable approach [tuberculin sensitivity test (TST) using the Mantoux method, culture from blood, pleural or spinal fluid specimen, and radiograph]. Two articles measured infectious skin conditions^{35,36} ‘in part’ in a standardised and reliable way (clinical examination of the body by a consultant dermatologist and venereologist). The validity and reliability of the outcome measure for the two studies examining communicable illness presentations to a prison clinic,^{27,37} was deemed poor. This is because presentations to a prison clinic may additionally capture other parameters of health service use besides and beyond health effects such as, dispositional characteristics of prisoners and the administration of medical care in the prison.³⁷

Although the sampling framework was described well in most studies, the sampling method was absent in two articles^{35,36} and response rates were not reported in four articles.^{27,35-37} Self-report measures were used in all studies to determine potential confounders such as underlying medical conditions and demographic information, therefore recall bias is a possibility. With the exception of the case-control and cohort studies (case-control: N=25 cases/75 controls; cohort: N=46),³³ sample sizes were relatively similar across the five cross-sectional studies (N=289-425). Three studies considered or adjusted for confounding factors or effect modifiers in the analyses;^{27,34,37} two studies did not,^{35,36} and it is unclear whether multivariate analysis was conducted in one study.³³

Evidence of an association between cell spatial density and infectious and communicable diseases

While the review found mostly consistent evidence that cell spatial density is associated with clinically verifiable infectious and communicable diseases, with five articles reporting a statistically significant association between cell spatial density and infectious and

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communicable diseases (Table 3), all but one of these associations could possibly being explained by chance, study bias or confounding.

In the study which investigated MTB infection in a random sample of 425 male prisoners in five Pakistan prisons, the association between cell spatial density and MTB was reported to be statistically significant (aOR 2.6; 95%CI: 1.6, 4.3) after adjusting for age, education, length of incarceration, tobacco use and other variables.³⁴ However, caution is warranted when interpreting this result due to the possible exposure and outcome misclassification. That is, the cell spatial density measure was a dichotomised average floor area per person (i.e. $>5.6\text{m}^2$ per person and $\leq 5.6\text{m}^2$ per person) and thus may be a crude measure. The study does not report on how this measure was determined. Additionally, the 100% response rate to the screening suggests possible coercion to participate in the study that may have affected the reliability of self-report data (e.g. household income, occupation).

One US' study investigating a pneumococcal disease outbreak³³ examined the disease attack rate and its association with cell spatial density. Although more clarity and consistency in reporting of the analysis is needed to properly assess the findings, the results indicate that the attack rate was highest in 4-person cells (2.9m^2 per person) compared with the two other cell types described (single cells at 4.2m^2 per person and open dormitories at 2.6m^2 per person). The study also reports that detainees housed in shared and single areas $\geq 7.4\text{m}^2$ per person (8% of the inmate population) had significantly fewer cases of pneumococcal disease than all other detainees (attack rate: 0 vs. 4.7 per 1000 persons; $p=0.03$). This lower attack rate for detainees housed in shared areas $\geq 7.4\text{m}^2$ per person may in part be explained by time spent outside cells as those housed in this area were engaged in work programs and left their cells to undertake such work. Results were inconsistently reported across cell types with both univariate and adjusted odds ratios reported for the different cell types suggesting that some results were adjusted for and some not.

In the two studies conducted with mostly male (97%) prisoners in Nigeria, the prevalence of infectious and non-infectious skin conditions among prisoners living in single cells (0.9m² per person) and dormitories (2.4m² per person) was significantly different at 61.7% vs. 43.2%³⁵ and 82.9% vs. 69.7%.^{35,36} However, the quality for these studies was assessed as ‘poor’ due to the absence of any multivariate analysis, no details of whether those conducting the physical examinations were blinded to the cell assignments of the prisoners, no response rates or sampling method described, and cell type details derived from self-report questionnaires.

Two other US’ articles reporting on the association between cell spatial density and illness reporting at the prison clinic were from a research program spanning approximately ten years reporting on data collected from 1,400 prisoners from six federal prisons.^{37,38} Illness reporting rates were determined by dividing the number of days a participant was in a cell type (with a specific cell social or spatial density) by the number of visits to a clinic. Not all outcomes were measured at and/or reported for all prison sites, and prisoner population characteristics, sampling methods, response rates and analytical procedures are not consistently reported across and within publications. One article, the Danbury prison study, reported results on illness reporting by contagious status,²⁷ covering: venereal disease; eye, ear, nose, throat infections; cough, cold, flu; gastrointestinal, stomach problems; skin conditions; virus; chills and fever. However, the lack of detail on the statistical analysis means it is unclear if potential confounders and effect modifiers were adjusted for. Nonetheless, the findings reported a significant difference (although *p* values were not reported) in contagious illness reporting between those in single occupant cells of 4.5 and/or 5.6m² per person (0.03 reports per week) and those in dormitories with a spatial density of 4.6 and/or 5.5m² (0.06 reports per week) per person. As the reported cell spatial area range of these two cell types are nearly identical, this

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is likely to say more about the effect of social density (the number of individuals per cell) or cell type (dormitories versus singles) than it does on cell spatial density.

The second US' study from this research, examined cell spatial density in single occupancy cells alone in two federal prisons.³⁷ Using multiple linear regression analysis statistically significant effects were reported in only one of the prisons. For contagious illness, the cell spatial density variable was reported as not significant ($p=0.88$). However, the validity and reliability of the outcome measure used is questionable as the measure may capture other parameters of health service use besides health effects.

(Insert Table 3 here)

Discussion

Despite the attention that prison crowding receives, this review identified only six articles examining cell spatial density and infectious diseases. While the methodological approach adopted in this review ensured that that the largest number of peer-reviewed and grey literature publications were identified, some studies and outcomes may have been missed due to publication and outcome reporting bias. Some journals may be more likely to publish studies that report statistically significant results and overlook studies that are not consistent with previously published studies, present 'negative data' that disproves the investigators' hypothesis, as well results that could be interpreted to be of little interest or relevance to their readership.³⁸ Due to the difficulty in located study protocols, assessment of selective reporting of outcomes was not conducted. Thus, outcome reporting bias may also be present.

The identified six studies were conducted with mostly male prisoner populations in the US, Pakistan and Nigeria. Infectious and communicable disease outcomes reported included pneumococcal disease, MTB, skin conditions, and prisoner reporting of communicable illness

to the prison clinic. Five were cross-sectional studies and one was a combined case-control and cohort study.

Overall, the evidence concerning the association between prison cell spatial density and infectious and communicable disease effects was given a rating of ‘C’ on the NHMRC Evidence Rating Scale (ranging from ‘A’ to ‘D’) indicating that “*the body of evidence provides some support for an association between cell spatial density and infectious and communicable diseases but care should be taken in the interpretation of the findings*”.³⁰ The review found that there was mostly consistent evidence that cell spatial density is associated with clinically verifiable infectious and communicable diseases. Although all six studies reported a statistically significant association between cell spatial density and infectious and communicable disease effects (one study reporting a negative association), the quality of the studies was assessed as poor due to risk of exposure/outcome misclassification, bias, chance and/or confounding. However, the Pakistan study on MTB³⁵ adjusted for potential confounders and chance.

The cross-sectional design of five of these studies means the ability to assess causality is limited in that they were carried out at one given point in time and provide no indication of the sequence of events. As such, it remains unclear whether cell spatial density exposure preceded or followed the onset of infectious or communicable diseases reported in these studies. The associations and statistical precision observed in the articles suggest the possibility of a ‘slight’ health impact of cell spatial density on prisoners in regard to infectious diseases. However, it is possible that these associations are due to confounding, bias and/or chance. In addition, differences between the populations examined in these studies were apparent in terms of socio-cultural demographics, institutional settings and practices, and the background prevalence of infectious and communicable diseases outcomes in the respective countries (US, Nigeria, Pakistan, Australia). Studies were also conducted in different decades. These apparent

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differences restrict the generalisability and transferability of the observed effects to correctional contexts outside the countries where the reviewed studies were conducted.

Implications for researchers and policy makers

Further research is needed that addresses the confounding, bias and chance elements in studies examined by this review. In most studies, inadequate attempts were made to adjust for personal characteristics and/or prison-related factors as potential confounders. This acknowledges that cell spatial density, as an objective condition of crowding, is likely to be embedded in a complex interplay of psychological, social, cultural and institutional factors, and that variations of any health effects cannot be fully understood without their consideration. Future research should incorporate more extensive data and analyses on prospective mediating factors and how they interact with cell spatial density and health effects.

Although the body of evidence assessed indicated cautious support for the association between prison cell spatial density and infectious and communicable diseases, we do not advocate increasing social and spatial density and there is likely to be reasonable grounds for policy responses to address prison crowding in the absence of scientific certainty. As one US' Court of Appeals⁴⁰ ruling stated:

Undoubtedly, certainty is the scientific ideal - to the extent that even science can be certain of its truth. But certainty in the complexities of environmental medicine may be achievable only after the fact, when scientists have the opportunity for leisurely and isolated scrutiny of an entire mechanism. Awaiting certainty will often allow for only reactive, not preventive regulation.

In the absence of scientific certainty, international standards and recommendations provide guidance by way of mitigating prison and prison cell crowding and any potential infectious and communicable disease effects this may bring. The International Red Cross Association (ICPA) handbook on *Water, Sanitation, Hygiene and Habitat in Prisons* recognises that any technical

focus on prisons to address potential adverse health effects, such as cell spatial density, cannot be separated from addressing other factors that mediate prisoner health and wellbeing.¹⁷ Some ICPA guidelines and recommendations are feasible in terms of implementation in the short term to address immediate need (e.g. access to health care and sanitary facilities and extending time ‘out-of-cell’ to participate in meaningful activities). A public health approach to addressing any adverse health effects associated with prison cell crowding should include prevention strategies ranging from the micro- to the macro-level. The United Nations’ Office of Drugs and Crime *Handbook on Strategies to Reduce Overcrowding in Prisons*¹³ acknowledges that to address the health effects associated with crowding, ‘decarceration’ strategies to prevent prison crowding occurring in the first instance is required. Decarceration strategies involve processes that remove people from prisons and prevent them from (re)entering prison. This is likely to be a longer-term strategy that will require extensive work involving multiple agencies from different sectors, and changes in political and societal attitudes to incarceration.

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Contributions

PLS is the guarantor. PLS, MS, AA and TGB drafted the manuscript. All authors contributed to the development of the selection criteria. PLS, MS and TGB contributed to the risk of bias assessment strategy, data extraction templates and developed the search strategies. All authors read, provided feedback and approved the final manuscript.

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Ethics

Ethics approval was not required. Please see 'Ethical approval for literature reviews and meta-analyses' on the UNSW Sydney Research Ethics & Compliance Support Frequently Asked Questions (FAQs) page (<https://research.unsw.edu.au/frequently-asked-questions-faqs>).

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study/review being reported; that no important aspects of the study/review have been omitted; and that any discrepancies from the study/review as planned have been explained.

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comprised of diverse stakeholders, including medical practitioners, infectious diseases experts, public health professionals, a custodial administrator and academic staff. Author and custodial administrator LG, who although contributed to the scope of the search criteria and provided feedback and approval of the final manuscript, did not contribute to data extraction, confounder, bias and chance assessment, aggregated evidence appraisal and ratings and the interpretation of findings.

Competing interest statement

There was grant support from the New South Wales Department of Justice during the conduct of the study. There are no financial relationships with any other organisations that might have an interest in the submitted work in the previous three years. Author LG is a custodial administrator LG and could give the appearance of potentially influencing findings. Although LG contributed to the scope of the search criteria and provided feedback and approval of the final manuscript, he did not contribute to data extraction, confounder, bias and chance assessment, aggregated evidence appraisal and ratings and the interpretation of findings.

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Tables and Figures

Table 1. Objective prison crowding measures identified in the literature

Measure	Example of study utilising measure
i. Prisoner population divided by the design capacity of the prison	McCorkle et al, 1995 ⁴⁰
ii. Prisoner population divided by the rated capacity of the prison	Tartaro, 2002 ⁴¹
iii. Percentage of prison cells or dormitories reported as overcrowded by the institution	Anson, 1984 ⁴²
iv. Prisoner population divided by the total number of available beds	Bonta & Kiem, 1978 ⁴³
v. Number of prisoners per prison	Ruback & Carr, 1984 ⁴⁴
vi. Number of prisoners per living space/cell unit (including communal areas)	Atlas, 1982 ⁴⁵
vii. Number of prisoners per cell	Urrego et al, 2015 ⁴⁶
viii. Number of square metres of the total prison floor area per person	Ekland-Olsen et al, 1983 ⁴⁷
ix. Number of square metres of the total living space/cell unit of the prisoner (including communal areas) per person	Megargee, 1977 ⁴⁸
x. Number of square metres of the cell per person	McCain, Cox & Paulus, 1976 ⁴⁹

Table 2. Search terms used to identify evidence to inform the systematic review (example for PubMed database)

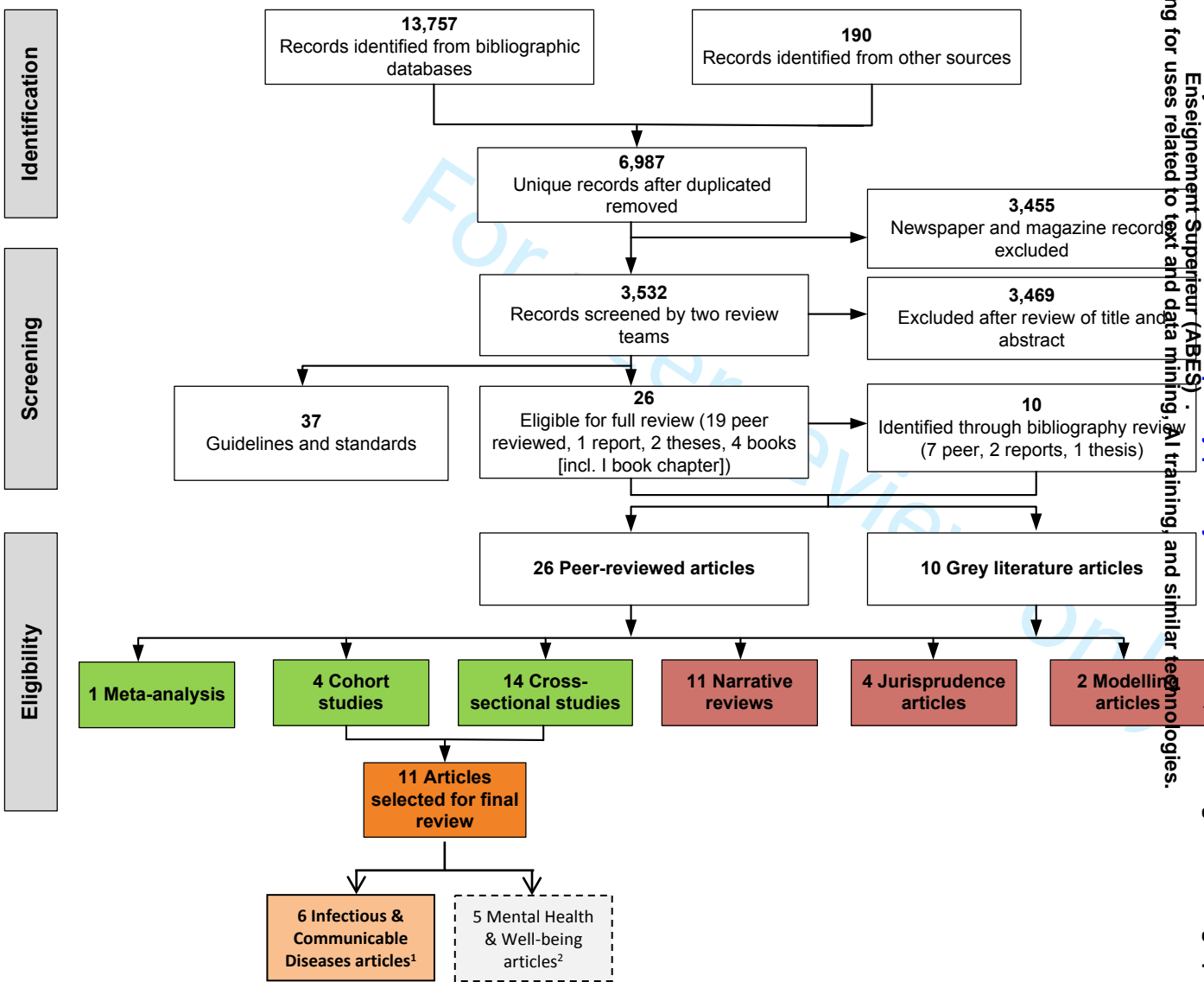
	Academic databases
Search terms	prison OR “corrective service*” OR “correctional cent*” OR “correctional complex” OR “correctional facilit*” OR borstal OR jail* OR gaol* OR penitentiary OR “detention cent*” OR custody OR custodial OR “closed setting*” AND accommodation OR cell OR room OR cubicle OR dormitory OR *crowding OR “social density” OR “spatial density” AND health OR illness OR sickn* OR infectio* OR transmissi* OR disease* OR hepatitis OR HIV OR tuberculosis OR parasite* OR bacteria* OR virus OR viral OR influenz* OR gastroent* OR disorder OR depressi* OR stress OR anxiety OR aggression OR irritability OR violence OR self-harm OR suicide OR well-being OR wellbeing AND prisoner* OR inmate* OR incarcerated OR criminal* OR felon* OR remandee* OR delinquent* OR detainee* OR convict* OR cellmate*
	Targeted grey literature
Search terms#	Prison cell and health effects, prison cell and health, jail cell and health, jail cell and health effects, prison cell and health and size, jail cell and health and size
#Search terms varied according to website, only some examples are provided	

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Table 3. Effect size or p value (test of difference) of outcomes for cell spatial density exposure values in eligible studies

Study	Sample (N, country)	Cell spatial density values (m ² per person)	Health outcome	Effect size or p value
Hussain et al. (2003) ³⁴	425, Pakistan	>5.6 vs ≤5.6	Mycobacterium tuberculosis	aOR 2.6; 95%CI 1.6, 4.3
Hoge et al. (1989) ³³	46 (cohort), US	2.9 vs 4.2 & 2.6 13.0 vs (2.9, 4.2 & 2.6); 6.8 vs (2.9, 4.2 & 2.6)	Pneumococcal disease	aOR 2.0; 95%CI 1.1, 3.8 p<0.001 p<0.001
Oninla & Onayemi (2012) ³⁵	305, Nigeria	0.9 vs 2.4	Infectious dermatoses	p=0.03
Oninla et al. (2013) ³⁶	305, Nigeria	0.9 vs 2.4	Infectious and non-infectious dermatoses	p<0.001
McCain et al. (1980) ⁴⁹	289, US	4.5/5.6 vs 4.6/5.5	Contagious illness reporting at clinic	p<0.05
Gaes (1982) ³⁷	352, US	4.0 to 8.2	Contagious illness reporting at clinic	ns
Bold = statistical significance ns = not statistically significant				

Figure 1. Study selection process



¹ Articles included for review

² Review of mental health and wellbeing articles reported elsewhere²⁹

Appendix A

Components of the Body of Evidence Statement Form used in the review

Component	A	B	C	D
	Excellent	Good	Satisfactory	Poor
Evidence base ¹	One of more level I studies with a low risk of bias or several level II studies with a low risk of bias	One or two level II studies with a low risk of bias or SR/several level III studies with a low risk of bias and confounding	One or two level III studies with a low risk of bias or level I or level II studies with a moderate risk of bias or confounding	Level IV studies or level III studies/SRs with a risk of bias and confounding
Consistency	All studies consistent	Most studies consistent and inconsistency can be explained	Some inconsistency, reflecting genuine uncertainty around question	Evidence is inconsistent
Population health impact	Very large	Moderate	Slight	Restricted
Generalisability	Evidence directly generalisable to target population	Evidence directly generalisable to target population with some caveats	Evidence not directly generalisable to the target population but could be sensibly applied	Evidence not directly generalisable to the target population and hard to judge whether it is sensible to apply
¹ Evidence base level: systematic review of prospective cohort studies (level I), prospective cohort study (level II), 'all or none' study (level III-1) retrospective cohort study (level III-2), case-control study (level III-3), cross-sectional study, or case series (level IV). ³¹				

Source: NHMRC³¹

Appendix B

Evidence Scale and Statement recommendations

Evidence statement rating	Description
A	Findings from the body of evidence can be trusted
B	Findings from the body of evidence can be trusted in most situations
C	The body of evidence provides some support but care should be taken in the interpretation of the findings
D	The body of evidence is weak and findings cannot be trusted

Source: NHMRC³¹

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PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol

Section and topic	Item No	Checklist item	Location in manuscript
ADMINISTRATIVE INFORMATION			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	See page 1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	Not applicable
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	Not applicable
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical address of corresponding author	See title page; see entry on Manuscript Central for email addresses
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	See title page and Contributions section (page 17)
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	Not applicable
Support:			
Sources	5a	Indicate sources of financial or other support for the review	See Funding section on (page 17)
Sponsor	5b	Provide name for the review funder and/or sponsor	See Funding section on (page 17)
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	See Funding section on (page 17-18)
INTRODUCTION			
Rationale	6	Describe the rationale for the review in the context of what is already known	See Introduction section (pages 3-4)
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	See final paragraph before Method section (page 5)
METHODS			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	See Methods section (Search strategy and selection criteria and Study eligibility subsections, pages 6-7)
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, registers or other grey literature sources) with planned dates of coverage	See Methods section (Search strategy and selection criteria subsection, pages 6-7)
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits	See Table 2

		such that it could be repeated		
Study records:				
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review		See Methods section (page 7)
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)		See Methods section (Study eligibility subsection, pages 7-8)
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently in duplicate), any processes for obtaining and confirming data from investigators		See Methods section (Critical appraisal of eligible studies subsection, page 8)
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources) and pre-planned data assumptions and simplifications		See Methods section (Critical appraisal of eligible studies subsection, page 8)
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale		See Methods section (Search strategy and selection criteria subsection, pages 6)
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether it will be done at the outcome or study level, or both; state how this information will be used in data synthesis		See Methods section (Critical appraisal of eligible studies subsection, pages 8-9)
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised		Not applicable
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2 , Kendall's τ)		Not applicable
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)		Not applicable
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned		See Methods section (Critical appraisal of eligible studies subsection, pages 8-9)
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)		See Discussion section (page 13)
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)		See Methods section (Critical appraisal of eligible studies subsection, pages 8-9)

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647.

BMJ Open

Prison cell spatial density and infectious and communicable diseases: a systematic review

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-026806.R1
Article Type:	Research
Date Submitted by the Author:	09-Apr-2019
Complete List of Authors:	Simpson, Paul; University of New South Wales - Randwick Campus, Kirby Institute Simpson, Melanie; Juvenile Justice New South Wales Adily, Armita; University of New South Wales - Randwick Campus, Kirby Institute Grant, Luke; New South Wales Department of Justice, Corrective Services New South Wales Butler, Tony; University of New South Wales - Randwick Campus, Kirby Institute
Primary Subject Heading:	Infectious diseases
Secondary Subject Heading:	Public health
Keywords:	Communicable Diseases, Public health < INFECTIOUS DISEASES, Prisons, Prisoners, Crowding, Spatial Density

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Prison cell spatial density and infectious and communicable diseases: a systematic review

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Prison cell spatial density and infectious and communicable diseases: a systematic review

Objective: To summarise the extent and quality of evidence on the association between prison cell spatial density (a measure of crowding) and infectious and communicable diseases transmission among prisoners.

Design: Systematic review.

Data sources: Embase, PubMed, Medline, Scopus, Web of Science, PsycInfo, PsycExtra, Proquest Databases, Proquest Dissertations and Theses Global, Index to Legal Periodicals, Informit Online, Cochrane Library, Criminal Justice Abstracts and ICONDA were searched to 31 December 2018.

Eligibility Criteria: Studies that reported on the association between prison cell spatial density (measured in square feet or square metres of cell floor area per person) and infectious and communicable diseases in juvenile and adult populations incarcerated in a correctional facility.

Data extraction and synthesis: A review protocol was developed in consultation with an advisory panel. Two reviewers independently extracted data and used the Australian National Health and Medical Research Council's (NHMRC) checklist to critically appraise individual studies. An assessment of the overall body of the evidence was conducted using the NHMRC's Evidence Scale and Statement Form.

Results: A total of 5,126 articles were initially identified with seven included in the review from Pakistan (2003), Chile (2016), Nigeria (2012, 2013) and the United States (1980s). Infectious and communicable disease outcomes included pneumococcal disease/acute pneumonia, mycobacterium tuberculosis, latent tuberculosis infection, infectious skin conditions, and contagious disease reporting to the prison clinic. Five articles reported statistically significant positive associations but were countered by associations possibly being explained by chance, bias or confounding factors. Heterogeneity prevented meta-analysis.

Conclusion: Overall, the body of evidence provides some support for an association between prison cell special density and infectious and communicable diseases, but care should be taken in the interpretation and transferability of the findings. Future research and policy responses should adequately consider prospective mediating factors implicated in associations between cell spatial density and health effects.

Key words: Communicable Diseases; Infectious Diseases; Prisons; Prisoners; Crowding; Spatial Density

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Strengths and limitations of this study

- This is the first systematic review of the association between prison cell spatial density (a measure of crowding) and infectious and communicable diseases.
- We used an expert advisory panel to guide review protocols and the Australian National Health and Research Council frameworks to evaluate the strength and quality of the evidence.
- Most included studies had incomplete reporting of methodology and findings.
- This review was limited by the small number of studies in this area and the heterogeneity of study design.

Introduction

Globally, the number of prisoners is increasing. Two percent above world population growth,¹ since the year 2000 the world's prisoner population has grown by approximately 20%, imposing a significant financial burden on society and having profound social and health consequences.² More than 11 million people are held in penal institutions globally, either as remand (pre-trial detainees) or convicted prisoners. Currently, seventeen countries in the world have an incarceration rate of more than 400 per 100,000 population in prison. The United States (US) is the largest incarcerator, accounting for approximately 20% of the world's prisoners with an incarceration rate of 655 per 100,000 population.³

A rising prison population without a corresponding expansion of infrastructure has raised health concerns in many countries over prison crowding,³ making prison cell size a key public health issue. For example, in the Australian state of New South Wales (NSW), prison cell size as a public health issue emerged in recent times with the publication of the Inspector of Custodial Services' report Full House: the growth of the inmate population in NSW⁴, the increase in the prisoner population, and the issue that a significant number of prison cells did not meet public health regulations on the minimum floor area requirements per prisoner. Historically, Corrective Services NSW had been exempted from such regulation provided a range of conditions imposed by the NSW Ministry of Health were met. In 2012, the Ministry required the NSW Department of Justice, Corrective Services to engage an independent [from Corrective Services] group to review the international literature on prison cell crowding and adverse health effects, a review of the international cell size guidelines, and a review of health surveillance data to advise the Ministers for Health and Justice.

Close physical proximity in confined spaces such as in prisons has been reported to be associated with an increased risk of infectious and communicable disease transmission including, mycobacterium tuberculosis, scabies, pneumococcus, meningococcus and

influenza.⁵⁻⁷ Rates of infectious diseases in prisons, particularly blood-borne viral infections (HIV and viral hepatitis) and airborne infections such as mycobacterium tuberculosis are typically higher than in the general community which exacerbates the risk of disease transmission.^{6,8,9} Additionally, it has been suggested that the close physical proximity in prisons may induce psychological stress or intensify the existing stressful conditions in a prison^{10,11} leading to alterations in immune and cardiovascular functions.¹²

The concept of crowding is understood in the academic literature and legislation as a mechanism that impacts adversely on the health and well-being of prisoners. Reports on prison conditions, prison standards and guidelines by international and regional agencies cite prison crowding as major health and human rights concerns impacting on this population.¹³⁻¹⁷ Left untreated in prison, the risk of disease transmission to family, friends, intimate partners, and other community members is likely upon leaving prison and returning to general society.¹⁸⁻²²

Despite decades of research dedicated to prison conditions and its impact on health, there has been no systematic review to assess the quality of evidence of the association between prison crowding and infectious and communicable disease transmission. A lack of consensus exists on the best way to conceptualise and measure the essential element(s) of crowding with the debate centring on the need for objective versus subjective measurements of crowding.^{23,24} The latter focuses on the individual experience or perception of crowding using subjective ratings of conditions such as behavioural constraints, stimulus and cognitive overload, privacy, desire to augment space, and loss of environmental control.^{12,25,26} The former, objective measures of prison crowding vary, but commonly revolve around metrics of prisoners per allocation of space to derive a measure of density (Table 1).

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Table 1. Objective prison crowding measures identified in the literature

Measure	Example of study utilising measure
i. Prisoner population divided by the design capacity of the prison	McCorkle et al, 1995 ²⁷
ii. Prisoner population divided by the rated capacity of the prison	Tartaro, 2002 ²⁸
iii. Percentage of prison cells or dormitories reported as overcrowded by the institution	Anson, 1984 ²⁹
iv. Prisoner population divided by the total number of available beds	Bonta & Kiem, 1978 ³⁰
v. Number of prisoners per prison	Ruback & Carr, 1984 ³¹
vi. Number of prisoners per living space/cell unit (including communal areas)	Atlas, 1982 ³²
vii. Number of prisoners per cell	Urrego et al, 2015 ³³
viii. Number of square metres of the total prison floor area per person	Ekland-Olsen et al, 1983 ³⁴
ix. Number of square metres of the total living space/cell unit of the prisoner (including communal areas) per person	Megargee, 1977 ³⁵
x. Number of square metres of the cell per person	McCain, Cox & Paulus, 1976 ³⁶

Some of these measures have been criticised as being amenable to manipulation by prison authorities and thus regarded as invalid measures of prison crowding.^{37,24} Measures iv. to x. (Table 1) are regarded as objective measures of social and spatial density. *Social density* refers to the number of people in a defined area of the prison (e.g. the whole facility, wing, dormitory, or cell). *Spatial density* refers to the floor area of a defined area (e.g. entire prison or cell) divided by the number of people in that space¹¹. Social and spatial densities are often dependent on one another, such as when the cell occupancy level increases, this causes a corresponding increase in both social density and spatial density. In this review, the area (measured in square feet or square metres) of the cell per person was selected as the cell crowding measure and is referred to as *cell spatial density*. This measure was adopted for two reasons. Firstly, the lack of consensus in the academic literature on the conceptualisation and measurement of crowding impressed the need to define cell crowding as an objectively defined environmental factor. Secondly, an examination of international guidelines on prison

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3 conditions and standards over the last half a century has seen a shift towards standards based
4 on cell spatial density (see Simpson, Simpson and Butler, 2016). Cell spatial density as a metric
5 has also entered the legislative domain such as in the Australian Capital Territory's *Human*
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10 *Rights Act 2004* which recommends 8.9m² for single cells and 10.7m² for double cells.¹⁶
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12 To determine the extent and quality of evidence on the association between prison cell
13 crowding and health impacts, Kirby Institute researchers and authors (PLS, MS, AA and TGB)
14 were commissioned by the New South Wales Department of Justice, Correctives Services to
15 conduct a systematic review of studies that analysed the association between prison cell spatial
16 density and prisoner infectious and communicable diseases and mental health and well-being
17 outcomes. In this paper we present the results of our review of the association between cell
18 spatial density and prisoner infectious and communicable disease effects, expressed in terms
19 of the evidence of this association and the quality of the evidence.
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31 **Methods**

32 Under the direction of the NSW Ministry of Health and the NSW Department of Justice, an
33 expert advisory panel was formed to guide the review comprising infectious diseases experts,
34 public health professionals, academic staff and custodial administrators. A review protocol was
35 developed following consultations with the advisory panel covering search strategy and
36 selection criteria and study eligibility and appraisal. The Preferred Reporting Items for
37 Systematic Reviews and Meta-Analyses (PRISMA) Guidelines was adopted for the review.³⁸
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47 ***Search strategy and selection criteria***

48 A search string was agreed to identify articles on the association between cell spatial density
49 and infectious and communicable diseases and mental health outcomes (Table 2). For the
50 present paper, articles reporting on infectious and communicable disease outcomes were
51 extracted from the final list of eligible studies. Review of the mental health outcome studies
52 are reported elsewhere.³⁹ Infectious and communicable diseases are defined 'as an illness due
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to a specific infectious agent or its toxic products that arises through transmission of such agent or products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or inanimate environment'.⁴⁰

The scope of the search was limited to the availability of an English abstract and to human subjects. Publication date was not restricted. Studies were excluded if they did not specify cell size or a measurement of cell spatial density, examined only temporary accommodation within custodial settings such as segregation cells, police cells, lockups, prison transport/transfer units, and prison clinic accommodation. Studies examining combined living and sleeping space preventing the differentiation of sleeping space were also excluded from the current review.

Fourteen medical, social science and architectural databases were searched: EMBASE (1947-2018), PubMed (≈1800-2018), Medline (1946-2018), Scopus (1976-2018), PsycInfo (1806-2018), PsycExtra (1908-2018), Web of Science (1900-2018), Proquest Databases (1763-2018), Proquest Dissertations and Theses Global (1716-2018), Index to Legal Periodicals (1985-2018), Informit Online (1920-2018), Cochrane Library (≈1900-2018), Criminal Justice Abstracts (1910-2018) and ICONDA (1976-2018). Grey literature was also identified from these database searches; and a further search for grey literature was conducted using Google and selected websites including those of the United Nations, International Committee of the Red Cross, Amnesty International, International Centre for Prison Studies, World Health Organization, Campbell Collaboration, the Criminal Justice Reference Service, the United States' (US) National Library of Medicine and websites of the Australian Inspector of Custodial Services. A number of international experts in the prisoner health area were contacted to inquire as to whether they were aware of additional material of potential interest to the review.

To manage records identified, articles were exported from databases into EndNote X7.1. Grey literature from non-database sources were entered into Endnote manually. PDF versions of articles were located and attached to Endnote items.

Table 2. Search terms used to identify evidence to inform the systematic review (example for PubMed database)

	Academic databases
Search terms	prison OR “corrective service*” OR “correctional cent*” OR “correctional complex” OR “correctional facilit*” OR borstal OR jail* OR gaol* OR penitentiary OR “detention cent*” OR custody OR custodial OR “closed setting*” AND accommodation OR cell OR room OR cubicle OR dormitory OR *crowding OR “social density” OR “spatial density” AND health OR illness OR sickn* OR infectio* OR transmissi* OR disease* OR hepatitis OR HIV OR tuberculosis OR parasite* OR bacteria* OR virus OR viral OR influenz* OR gastroent* OR disorder OR depressi* OR stress OR anxiety OR aggression OR irritability OR violence OR self-harm OR suicide OR well-being OR wellbeing AND prisoner* OR inmate* OR incarcerated OR criminal* OR felon* OR remandee* OR delinquent* OR detainee* OR convict* OR cellmate*
	Targeted grey literature
Search terms#	Prison cell and health effects, prison cell and health, jail cell and health, jail cell and health effects, prison cell and health and size, jail cell and health and size
#Search terms varied according to website, only some examples are provided	

Study eligibility

All publications identified by the search were first screened by two independent teams of two reviewers (PLS, AA, and MS, LY). To ensure consistency in the screening process and selection of eligible studies across the teams, titles and abstracts of the first 100 studies were independently reviewed by both teams and discussed as a group to ensure consistency. After achieving a consensus on eligibility for full text review across both teams, the remaining articles were divided between the two teams of reviewers. Each person within the team independently reviewed their assigned literature, and upon finishing, discussed the eligibility outcome with the other team member. In those instances where there was disagreement within a team, both teams met to resolve the issues and decide through consensus if the article was eligible for full text review.

Articles were excluded from full text review if the study design did not feature in the Australian National Health and Medical Research Council's (NHMRC) Hierarchy of Evidence.⁴¹ This hierarchy includes systematic reviews of prospective cohort studies (level I evidence), prospective cohort study (level II evidence), 'all or none' study (i.e. either all or none of the people with the risk factor(s) experienced the outcome of interest) (level III-1 evidence) retrospective cohort study (level III-2 evidence), case-control study (level III-3 evidence), or cross-sectional study or case series (level IV evidence).⁴¹ Articles were also excluded if they did not conduct an analysis that examined the relationship between the exposure variable of prison cells accommodating one or more persons with a specified cell spatial density or cell dimensions and an outcome variable of an infectious and/or communicable disease.

Critical appraisal of eligible studies

Critical appraisal of eligible studies involved three stages: (i) data extraction,⁴² (ii) assessment of bias, chance and confounding,⁴³ and (iii) an aggregated assessment of all studies using the

NHMRC FORM Matrix and Evidence Statement to produce a final rating and evidence statement.⁴¹

An adapted version of the NHMRC’s standardised data summary table was used to extract data.⁴² Data extraction tables were prepared and cross-checked by two independent reviewers (PLS, MS). Extracted information included: general study details (citation, study design, length of follow-up, level of evidence, and location and setting); study exposure and control descriptions; population characteristics; internal and external validity considerations; and study outcomes and results.

Assessment of bias, chance and confounding was guided by the NHMRC’s checklist to critically appraise aetiology or risk factor studies.⁴³ Checklist items used to guide the assessment of studies included: exposure misclassification; outcome misclassification; selection bias; confounding; and chance. Items were assessed on one of two 3-point scales: low (0), medium (1), high (2) risk; or poor (0), fair (1), good (2).

A systematic assessment of the overall body of the evidence was conducted using a modified (for study population relevance) NHMRC FORM Matrix and Evidence Statement covering:³¹ 1) evidence base; 2) consistency of results; 3) population health impact; and 4) generalisability. Each component was rated from Excellent to Poor (Appendix A) to allow a final overall rating and evidence statement to be derived ranging from ‘A’ to D’: ‘A’ indicating that the body of evidence can be trusted to ‘D’ indicating that the body of evidence is weak, and findings cannot be trusted. (Appendix B).⁴¹ The final overall rating and evidence statement were undertaken by one reviewer (PLS) and cross-checked by another (MS).

Following the completion of the review by the team, an expert, independent of the reviewers and advisory panel, peer reviewed the methodology and findings.

Patient and public involvement

Patients and the public were not involved in the review.

Results

After removing duplicate records and newspaper and magazine articles, a total of 5,126 records were assessed for eligibility based on publication title and abstract content (Figure 1). As a result of this screening, 41 records that reported on infectious and communicable diseases and/or mental health outcomes were identified for full text review. For the present review, seven publications met the inclusion criteria for infectious and communicable disease outcomes; five articles were published in peer-reviewed journals⁴⁴⁻⁴⁸ and two were reports.^{37,49} Two articles related to the same research program on prison crowding,^{37,49} two articles derived from the same study on infectious skin conditions.⁴⁶⁻⁴⁷ Five articles examined the association between cell spatial density and pneumococcal disease or acute pneumonia,⁴⁴ mycobacterium tuberculosis (MTB),⁴⁵ latent tuberculosis infection (LTBI),⁴⁸ and infectious skin conditions,⁴⁶⁻⁴⁷ respectively, while two articles reported on communicable illness presentation to the prison clinic.^{37,48} Three studies were conducted in the United States of America (US),^{37,44,49} two in Nigeria,^{46,47} one in Chile⁴⁸ and one in Pakistan (Table 3).⁴⁵ Meta-analysis was not possible due to heterogeneity and incomplete reporting of findings. Measures of effect reported in the six publications varied and included odds ratio, risk ratio, and mean and group differences.

Six studies were cross-sectional in design (level IV aetiology evidence) and one included both a case-control and cohort study design reported in the same article (level III-3/III-2 aetiology evidence). Outcome measures for the pneumococcal disease⁴⁴ and MTB⁴⁵ studies were measured using a standardised and reliable approach [tuberculin sensitivity test (TST) using the Mantoux method, culture from blood, pleural or spinal fluid specimen, and radiograph]. LTBI was measured using Interferon-Gamma Release Assays (IGRAs) and those found to be IGRA-positive underwent direct sputum smear microscopy and chest radiography to diagnose active TB or LTBI.⁴⁸ Two articles measured infectious skin conditions^{46,47} 'in part' in a standardised and reliable way (clinical examination of the body by a consultant

dermatologist and venereologist). The validity and reliability of the outcome measure for the two studies examining communicable illness presentations to a prison clinic,^{37,49} was deemed poor. This is because presentations to a prison clinic may additionally capture other parameters of health service use besides and beyond health effects such as, dispositional characteristics of prisoners and the administration of medical care in the prison.⁴⁹

Although the sampling framework was described well in most studies, the sampling method was absent in two articles^{46,47} and response rates were not reported in four articles.^{37,46,47,49} Self-report measures were used in six studies to determine potential confounders such as underlying medical conditions and demographic information, therefore recall bias is a possibility. With the exception of the case-control and cohort studies (case-control: N=25 cases/75 controls; cohort: N=46),⁴⁴ sample sizes were relatively similar across the five cross-sectional studies (N=289-428). Four studies considered or adjusted for confounding factors or effect modifiers in the analyses;^{37,45,48,49} two studies did not,^{46,47} and it is unclear whether multivariate analysis was conducted in one study.⁴⁴

Evidence of an association between cell spatial density and infectious and communicable diseases

While the review found mostly consistent evidence that cell spatial density is associated with clinically verifiable infectious and communicable diseases, with five articles reporting a statistically significant association between cell spatial density and infectious and communicable diseases (Table 3), all but one of these associations could possibly be explained by chance, study bias or confounding.

In the study which investigated MTB infection in a random sample of 425 male prisoners in five Pakistan prisons, the association between cell spatial density and MTB was reported to be statistically significant (aOR 2.6; 95%CI: 1.6, 4.3) after adjusting for age, education, length of incarceration, tobacco use and other variables.⁴⁵ However, caution is

warranted when interpreting this result due to the possible exposure and outcome misclassification. That is, the cell spatial density measure was a dichotomised average floor area per person (i.e. $>5.6\text{m}^2$ per person and $\leq 5.6\text{m}^2$ per person) and thus may be a crude measure. The study does not report on how this measure was determined. Additionally, the 100% response rate to the screening suggests possible coercion to participate in the study that may have affected the reliability of self-report data (e.g. household income, occupation).

The LBTI study was conducted in 46 prisons in Chile and included 418 prisoner and non-prisoner contacts of 33 active TB cases recruited 12 months following the identification of active TB cases.⁴⁸ The study found high TB incidence (123.9 per 100 000 prisoners) and high LTBI prevalence (29.4%) among contacts, with LTBI rates significantly higher in prisoners than in non-prisoners (33.2% vs. 15.6%). Multivariate analyses showed a significant association between cell spatial density and LBTI (aOR 3.5; 95%CI: 1.1, 11.5) after adjusting for gender, age, illicit drug use, history of corticosteroid use and malnutrition, and length of incarceration. Assessing the extent of potential exposure misclassification was difficult as the spatial density measure used in analysis is not reported (unclear if continuous or categorical variable used). Cell type (i.e. multiple-person cells, dormitories) across the different prisons was also not reported.

One US' study investigating a pneumococcal disease outbreak⁴⁴ examined the disease attack rate and its association with cell spatial density. Although more clarity and consistency in reporting of the analysis is needed to properly assess the findings, the results indicate that the attack rate was highest in 4-person cells (2.9m^2 per person) compared with the two other cell types described (single cells at 4.2m^2 per person and open dormitories at 2.6m^2 per person). The study also reports that detainees housed in shared and single areas $\geq 7.4\text{m}^2$ per person (8% of the inmate population) had significantly fewer cases of pneumococcal disease than all other detainees (attack rate: 0 vs. 4.7 per 1000 persons; $p=0.03$). This lower attack rate for detainees

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housed in shared areas $\geq 7.4\text{m}^2$ per person may in part be explained by time spent outside cells as those housed in this area were engaged in work programs and left their cells to undertake such work. Results were inconsistently reported across cell types with both univariate and adjusted odds ratios reported for the different cell types suggesting that some results were adjusted for and some not.

In the two studies conducted with mostly male (97%) prisoners in Nigeria, the prevalence of infectious and non-infectious skin conditions among prisoners living in single cells (0.9m^2 per person) and dormitories (2.4m^2 per person) was significantly different at 61.7% vs. 43.2%⁴⁶ and 82.9% vs. 69.7%.^{46,47} However, the quality for these studies was assessed as ‘poor’ due to the absence of any multivariate analysis, no details of whether those conducting the physical examinations were blinded to the cell assignments of the prisoners, no response rates or sampling method described, and cell type details derived from self-report questionnaires.

Two other US’ articles reporting on the association between cell spatial density and illness reporting at the prison clinic were from a research program spanning approximately ten years reporting on data collected from 1,400 prisoners from six federal prisons.^{37,49} Illness reporting rates were determined by dividing the number of days a participant was in a cell type (with a specific cell social or spatial density) by the number of visits to a clinic. Not all outcomes were measured at and/or reported for all prison sites, and prisoner population characteristics, sampling methods, response rates and analytical procedures are not consistently reported across and within publications. One article, the Danbury prison study, reported results on illness reporting by contagious status,³⁷ covering: venereal disease; eye, ear, nose, throat infections; cough, cold, flu; gastrointestinal, stomach problems; skin conditions; virus; chills and fever. However, the lack of detail on the statistical analysis means it is unclear if potential confounders and effect modifiers were adjusted for. Nonetheless, the findings reported a

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significant difference (although p values were not reported) in contagious illness reporting between those in single occupant cells of 4.5 and/or 5.6m² per person (0.03 reports per week) and those in dormitories with a spatial density of 4.6 and/or 5.5m² (0.06 reports per week) per person. As the reported cell spatial area range of these two cell types are nearly identical, this is likely to say more about the effect of social density (the number of individuals per cell) or cell type (dormitories versus singles) than it does on cell spatial density.

The second US' study from this research, examined cell spatial density in single occupancy cells alone in two federal prisons.⁴⁹ Using multiple linear regression analysis statistically significant effects were reported in only one of the prisons. However, for contagious illness, the cell spatial density variable was reported as not significant ($p=0.88$). However, the validity and reliability of the outcome measure used is questionable as the measure may capture other parameters of health service use besides health effects.

Table 3. Characteristics and quality assessment of included studies

Author	Year of publication	Country study was conducted	Type of study, sample size, gender	Outcome	Exposure characteristics	Effect size/measure (aOR or p value)	Overall quality and capacity to determine if cell spatial density is associated with outcome†
					Cell spatial density values analysed (m ² per person)	Cell design type	
Hussain et al. ⁴⁵	2003	Pakistan	Cross-sectional study, 425, 100% male	Mycobacterium tuberculosis	>5.6 vs ≤5.6	Bar chart (term not used and may refer to single &/or multiple person cells)	aOR 2.6; 95%CI 1.6, 4.3 Medium to high risk of: <ul style="list-style-type: none">• exposure misclassification• confounding Potential for: <ul style="list-style-type: none">• recall bias
Aguilera et al. ⁴⁸	2016	Chile	Cross-sectional study, 418, 77% male	Latent tuberculosis infection	Unclear if continuous or dichotomised variable used.	Not reported	aOR 3.5; 95%CI: 1.1, 11.5) Medium to high risk of: <ul style="list-style-type: none">• exposure misclassification Potential for: <ul style="list-style-type: none">• recall bias
Hoge et al. ⁴⁴	1989	United States of America	Cohort study, 46, 92% male	Pneumococcal disease	2.9 vs (4.2 & 2.6);	Single person (dormitory)	aOR 2.0; 95%CI 1.1, 3.8 Poor to fair Medium to high risk of:

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13	Oninla &	2012	Nigeria	Cross-sectional	Infectious	0.9 vs 2.4	Single	$p=0.03$	Poor
14	Onayemi ⁴⁶			study,	dermatoses		dormitories		High risk of:
15				305,					• associations
16				97% male					due
17									to chance
18									• confounding
19									• selection
20									bias
21									Potential for:
22									• recall bias
23									• exposure
24									misclassifica
25									tion
26									
27									
28	Oninla et al. ⁴⁷	2013	Nigeria	Cross-sectional	Infectious and	0.9 vs 2.4	Single	$p<0.001$	Poor
29				study,	non-infectious		dormitories		High risk of:
30				305,	dermatoses				• associations
31				97% male					due
32									to chance
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McCain et al. ³⁷	1980	United States of America	Cross-sectional study, 289, 100% male	Contagious illness reporting at clinic	4.5/5.6 vs 4.6/5.5	Singles vs cubed dormitory	<i>p</i> <0.05	<ul style="list-style-type: none">• exposure misclassification Fair Medium to high risk of: <ul style="list-style-type: none">• outcome misclassification Potential for: <ul style="list-style-type: none">• associations by chance• confounding• recall bias• selection bias
Gaes ⁴⁹	1982	United States of America	Cross-sectional study, 352, 100% male	Contagious illness reporting at clinic	4.0 to 8.2	Singles and cubed	ns	Poor to fair Medium to high risk of: <ul style="list-style-type: none">• outcome misclassification Potential for: <ul style="list-style-type: none">• confounding• selection bias
<p>Bold = statistical significance ns = not statistically significant † Assessment guided by the NHMRC’s checklist to critically appraise aetiology or risk factor studies.⁴² Checklist items used to guide the assessment included: exposure misclassification; outcome misclassification; selection bias; confounding; and chance.</p>								

Discussion

Despite the attention that prison crowding receives, this review identified only seven articles examining cell spatial density and infectious and communicable diseases. While the methodological approach adopted in this review ensured that the largest number of peer-reviewed and grey literature publications were identified, some studies and outcomes may have been missed due to publication and outcome reporting bias. Some journals may be more likely to publish studies that report statistically significant results and overlook studies that are not consistent with previously published studies, present 'negative data' that disproves the investigators' hypothesis, as well results that could be interpreted to be of little interest or relevance to their readership.⁵⁰ Due to the difficulty in located study protocols, assessment of selective reporting of outcomes was not conducted. Thus, outcome reporting bias may also be present.

The identified seven studies were conducted with mostly male prisoner populations in the US, Pakistan, Chile and Nigeria. Infectious and communicable disease outcomes reported included pneumococcal disease, MTB, LBTI, skin conditions, and prisoner reporting of communicable illness to the prison clinic. Six were cross-sectional studies and one was a combined case-control and cohort study.

Overall, the evidence concerning the association between prison cell spatial density and infectious and communicable disease effects was given a rating of 'C' on the NHMRC Evidence Rating Scale (ranging from 'A' to 'D') indicating that "*the body of evidence provides some support for an association between cell spatial density and infectious and communicable diseases but care should be taken in the interpretation of the findings*".⁴¹ The review found that there was mostly consistent evidence that cell spatial density is associated with clinically verifiable infectious and communicable diseases. Although five of the seven studies reported a statistically significant positive association between cell spatial density and infectious and

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communicable disease effects (one additional study reporting a significant association regarding the effect of social density or cell type rather than cell spatial density), the quality of the studies was assessed as poor due to risk of exposure/outcome misclassification, bias, chance and/or confounding. However, the Pakistan study on MTB⁴⁵ and the Chile Study on LBTI⁴⁸ adjusted for potential confounders and chance.

The cross-sectional design of six of these studies means the ability to assess causality is limited in that they were carried out at one given point in time and provide no indication of the sequence of events. As such, it remains unclear whether cell spatial density exposure preceded or followed the onset of infectious or communicable diseases reported in these studies. However, one study provided some evidence that a number of infections occurred inside prisons following a repeat testing performed at eight weeks after baseline, suggesting cell spatial density exposure contributed to these new infections.⁴⁸ The associations and statistical precision observed in the articles suggest the possibility of a ‘slight’ health impact of cell spatial density on prisoners in regard to infectious diseases. However, it is possible that these associations are due to confounding, bias and/or chance. In addition, differences between the populations examined in these studies were apparent in terms of socio-cultural demographics, institutional settings and practices, and the background prevalence of infectious and communicable diseases outcomes in the respective countries (US, Nigeria, Pakistan, Chile). Studies were also conducted in different decades. These apparent differences restrict the generalisability and transferability of the observed effects to correctional contexts outside the countries where the reviewed studies were conducted.

Implications for researchers and policy makers

Further research is needed that addresses the confounding, bias and chance elements in studies examined by this review. We recommend that future studies include clinically verifiable health outcomes to ensure outcome misclassification is prevented or minimised and include

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adequate detail on how cell floor spatial density was determined to facilitate a clear assessment of exposure misclassification.

In most articles reviewed, inadequate attempts were made to adjust for personal characteristics of prisoners and/or prison-related factors as potential confounders. This statement acknowledges that cell spatial density, as an objective condition of crowding, is likely to be embedded in a complex interplay of psychological, social, cultural and institutional factors, and that variations of any health effects cannot be fully understood without their consideration. Thus, future research should seek to collect more extensive data on prospective confounding and mediating factors to examine how such factors interact with cell spatial density and health effects. To assist this, we reviewed the twelve eligible articles identified in this review (seven) and the mental health and wellbeing review (five),³⁹ in addition to key international reports on prisoner conditions, prison crowding and prisoner health to identify what factors might mediate the association between prison cell spatial density and adverse health effects.⁵¹ From this review we recommend that future research on cell spatial density and health effects consider the following factors: (i) personal characteristics of prisoners such as age, education level, gender, ethnicity, underlying medical conditions, and health risk behaviours (e.g. current intravenous drug use); (ii) physical environment measures such as air ventilation and privacy afforded to the prisoner; and (iii) social and policy environment of prison such as time confined in cell per day, cell allocation policy and practice, health service access, length of incarceration and custody and security classification of prisoner.⁵¹

Although the body of evidence assessed indicated cautious support for the association between prison cell spatial density and infectious and communicable diseases, we do not advocate increasing social and spatial density and there is likely to be reasonable grounds for policy responses to address prison crowding in the absence of scientific certainty. As one US' Court of Appeals⁵² ruling stated:

Undoubtedly, certainty is the scientific ideal - to the extent that even science can be certain of its truth. But certainty in the complexities of environmental medicine may be achievable only after the fact, when scientists have the opportunity for leisurely and isolated scrutiny of an entire mechanism. Awaiting certainty will often allow for only reactive, not preventive regulation.

In the absence of scientific certainty, international standards and recommendations provide guidance by way of mitigating prison and prison cell crowding and any potential infectious and communicable disease effects this may bring. The International Red Cross Association (ICPA) handbook on *Water, Sanitation, Hygiene and Habitat in Prisons* recognises that any technical focus on prisons to address potential adverse health effects, such as cell spatial density, cannot be separated from addressing other factors that mediate prisoner health and wellbeing.¹⁷ Some ICPA guidelines and recommendations are feasible in terms of implementation in the short term to address immediate need (e.g. access to health care and sanitary facilities and extending time ‘out-of-cell’ to participate in meaningful activities). A public health approach to addressing any adverse health effects associated with prison cell crowding should include prevention strategies ranging from the micro- to the macro-level. The United Nations’ Office of Drugs and Crime *Handbook on Strategies to Reduce Overcrowding in Prisons*¹³ acknowledges that to address the health effects associated with crowding, ‘decarceration’ strategies to prevent prison crowding occurring in the first instance is required. Decarceration strategies involve processes that remove people from prisons and prevent them from (re)entering prison. This is likely to be a longer-term strategy that will require extensive work involving multiple agencies from different sectors, and changes in political and societal attitudes to incarceration.

Contributions

PLS is the guarantor. PLS, MS, AA and TGB drafted the manuscript. All authors contributed to the development of the selection criteria. PLS, MS and TGB contributed to the risk of bias assessment strategy, data extraction templates and developed the search strategies. All authors read, provided feedback and approved the final manuscript.

Acknowledgements

We would like to acknowledge Advisory Panel members Professor Wayne Smith and Dr Benjamin Scalley of the New South Wales Ministry of Health; Garry Forrest and Denise Monkley of the Justice Health and Forensic Mental Health Network; and Janaya Ho of Corrective Services New South Wales. We would also like to acknowledge the independent peer-review undertaken by Associate Professor Jeffrey Post, and Dr Lorraine Yap and Marina Talevski with respect to their contributions to this review.

Ethics

Ethics approval was not required. Please see 'Ethical approval for literature reviews and meta-analyses' on the UNSW Sydney Research Ethics & Compliance Support Frequently Asked Questions (FAQs) page (<https://research.unsw.edu.au/frequently-asked-questions-faqs>).

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study/review being reported; that no important aspects of the study/review have been omitted; and that any discrepancies from the study/review as planned have been explained.

Funding

Under the direction of the New South Wales Ministry of Health, the New South Wales Department of Justice funded this review. To ensure appropriate management of perceived or potential conflicts of interest, the expert advisory panel that was formed to guide the review

comprised of diverse stakeholders, including medical practitioners, infectious diseases experts, public health professionals, a custodial administrator and academic staff. Author and custodial administrator LG, who although contributed to the scope of the search criteria and provided feedback and approval of the final manuscript, did not contribute to data extraction, confounder, bias and chance assessment, aggregated evidence appraisal and ratings and the interpretation of findings.

Competing interest statement

There was grant support from the New South Wales Department of Justice during the conduct of the study. There are no financial relationships with any other organisations that might have an interest in the submitted work in the previous three years. Author LG is a custodial administrator LG and could give the appearance of potentially influencing findings. Although LG contributed to the scope of the search criteria and provided feedback and approval of the final manuscript, he did not contribute to data extraction, confounder, bias and chance assessment, aggregated evidence appraisal and ratings and the interpretation of findings. At the time of the review MS was employed as a research associate of the Kirby Institute, University of New South Wales, Sydney.

Data sharing statement

No additional data available.

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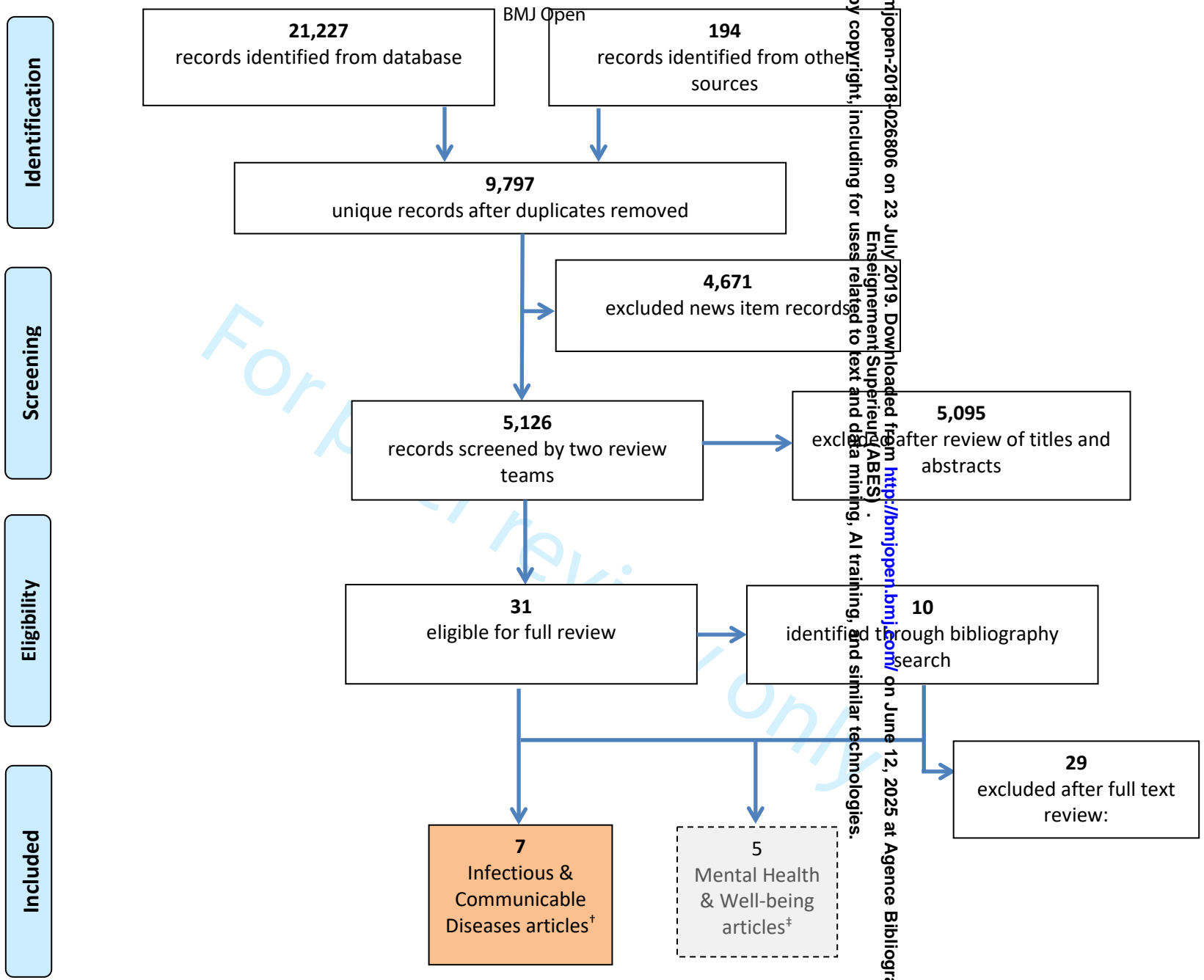
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Figure 1. Flow chart for selection of articles

For peer review only

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Figure 1. Study selection process



[†] Articles included for review

[‡] Review of mental health and wellbeing articles reported elsewhere²⁹

Appendix A

Components of the Body of Evidence Statement Form used in the review

Component	A	B	C	D
	Excellent	Good	Satisfactory	Poor
Evidence base ¹	One of more level I studies with a low risk of bias or several level II studies with a low risk of bias	One or two level II studies with a low risk of bias or SR/several level III studies with a low risk of bias and confounding	One or two level III studies with a low risk of bias or level I or level II studies with a moderate risk of bias or confounding	Level IV studies or level III studies/SRs with a risk of bias and confounding
Consistency	All studies consistent	Most studies consistent and inconsistency can be explained	Some inconsistency, reflecting genuine uncertainty around question	Evidence is inconsistent
Population health impact	Very large	Moderate	Slight	Restricted
Generalisability	Evidence directly generalisable to target population	Evidence directly generalisable to target population with some caveats	Evidence not directly generalisable to the target population but could be sensibly applied	Evidence not directly generalisable to the target population and hard to judge whether it is sensible to apply
¹ Evidence base level: systematic review of prospective cohort studies (level I), prospective cohort study (level II), 'all or none' study (level III-1) retrospective cohort study (level III-2), case-control study (level III-3), cross-sectional study, or case series (level IV). ³¹				

Source: NHMRC³¹

Appendix B

Evidence Scale and Statement recommendations

Evidence statement rating	Description
A	Findings from the body of evidence can be trusted
B	Findings from the body of evidence can be trusted in most situations
C	The body of evidence provides some support but care should be taken in the interpretation of the findings
D	The body of evidence is weak and findings cannot be trusted

Source: NHMRC³¹



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria; participants; and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Table 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	7-8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6, 8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8-9
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	9
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	13
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9 & Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, sex, follow-up period) and provide the citations.	Table 3
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	13-14
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	14-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14-16
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	17-18

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Correction: *Correction for Prison cell spatial density and infectious and communicable diseases: a systematic review*

Simpson PL, Simpson M, Adily A, *et al.* Prison cell spatial density and infectious and communicable diseases: a systematic review. *BMJ Open* 2019;9:e026806. doi: 10.1136/bmjopen-2018-026806

This article was previously published with errors. The authors noticed below errors:

- ▶ The acronym for the International Committee of the Red Cross presented in the last paragraph of the article (p. 8) should read ICRC and not ICPA.
- ▶ The guidelines stated in the last paragraph of the article (p. 8) should read ICRC guidelines.
- ▶ The initials of the reviewers who screened publications (p. 3) should read: PLS, AA and MS, TB.

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