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Rethinking standards on prison cell size in a (post)pandemic world: a scoping review

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ABSTRACT

Objective To describe the current international, regional and national standards on prison cell spatial density and the evidence for the association between COVID-19 transmission and prison crowding measures to provide recommendations on prison cell spatial density standards for a (post) pandemic world.

Design Scoping review.

Data sources PubMed, ProQuest, Informit, Criminal Justice Abstracts, Cochrane, Web of Science, Scopus, EMBASE, Google Scholar and Google were searched up to November 2021.

Eligibility criteria Guidelines were included provided they described standards of prison accommodation with respect to prison cells. Studies were included provided they examined an association between COVID-19 cases and a crowding measure.

Data extraction and synthesis Data were extracted by one reviewer and cross-checked by another. Quantitative and qualitative data on prison cell standards and characteristics of studies examining an association between COVID-19 and prison crowding were collected. Findings were synthesised qualitatively.

Results Seventeen reports and six studies met eligibility criteria. International and regional standards on cell spatial density were mostly qualitative, with two quantifiable international standards located (3.4 m^2 and 3.5 m^2 per person for multiple occupancy cells), and two quantifiable regional standards located (4 m^2 per person (Europe) and 5.75 m^2 or 4 m^2 per person (Australia and New Zealand)). Country-based standards varied substantially, ranging from 1.25 m^2 per person (Pakistan) to 10 m^2 per person (Netherlands). Consideration of airborne transmission of disease in prisons were mostly overlooked or absent to rationalise standards. There was consistent evidence that prison crowding measures were associated with COVID-19 transmission/cases.

Conclusion Considering the physics of respiratory emissions, we recommend prison cell spatial density standards be updated to reflect graded levels of risk that consider other factors that combine to inform airborne transmission risk. Decarceration strategies should be considered and become vital if standards are not met.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This scoping review collates and reviews international, regional and national standards on prison cell spatial density levels and available studies on the association between prison crowding and COVID-19 cases in prisons.
⇒ Quantitative prison cell spatial density standards were not located for many countries.
⇒ This review of studies examining associations between prison crowding and COVID-19 transmission in prisons COVID-19 was limited by the small number of studies.

INTRODUCTION

Prison guidelines and standards emerged in the 20th century to prevent the inhuman, cruel or degrading treatment or punishment, and the prevention of disease and death, of people in prisons. Given the emergence of COVID-19 outbreaks in prison globally, it is timely to re-examine prison standards with due consideration of spatial density within prisons and the physics of respiratory emissions behind airborne diseases to assess the risk of morbidity and mortality.

Historical events show that prisons are conducive to the spread of infectious diseases.[1] This is due to the unique characteristics of this environment such as large numbers of people confined in fairly small spaces, a high turnover of people due to constant admissions and releases, contact with the community through external medical appointments, work release programmes, court appearances and other staff who work in prisons, and the movement of incarcerated persons between and within prisons.[2] Incarcerated populations are also recognised as having a higher burden of underlying chronic health conditions, including immunocompromising diseases that may enhance vulnerability to infection.[3–5] Minority groups are typically overrepresented in incarcerated populations. Both imprisonment and COVID-19 have been reported to disproportionately impact on racialised, poor, ageing and gender diverse people who are targeted and contained within carceral systems owing to structural forms of discrimination and inequity.[6 7] Additionally, many prison health services are poorly resourced and so experience restrictions on their ability to deliver adequate and community-equivalent health services to patients in prison.[8]

Although COVID-19 has renewed interest in physical distancing in prisons, standards on minimum cell floor area per incarcerated person (ie, cell spatial density) have featured in guidelines predating COVID-19. The extent that understandings of airborne infectious diseases are drawn on to explain cell spatial density standards is largely unexplored in the literature. One study examining the contributions of evidence, expertise and politics to the development of the 2015 United Nations' (UN) Revised Standard Minimum Rules (SMR) for the Treatment of Prisoners (or the 'Mandela Rules'), reported that justification by experts for health issues in the Mandela Rules came largely from established evidence-based policy guidelines for the general community. Deliberations on infectious diseases focused mostly on bloodborne viruses such as HIV and hepatitis. Although tuberculosis was referenced by experts, its inclusion in the Mandela Rules, in terms of prevention measures, was confined to quarantine rather than spatial density measures.[9] Interestingly, cell space and overcrowding were reported priorities that Non-Government Organisations (NGOs) in the Global South wanted considered for the Mandela Rules and were framed in terms of contravening human dignity, rights and preventing 'the spread of illness'.[10] However, these issues were excluded from the final list of priorities to inform revisions to the Mandela Rules.[9]

There may be wider and intersecting political and historical factors contributing to why addressing airborne infectious disease prevention and overcrowding may be overlooked in justifying or defining cell size standards such as in the Mandela Rules. The development of the Mandela Rules has been viewed as a product of political compromises among jurisdictions with divergent resources and priorities.[9] Meeting cell size and cell spatial density standards justified by either the prevention of airborne infectious disease outbreaks or overcrowding is likely to be perceived by governments to be costly—economically and politically. Having compliant prisons is likely to be expensive and legal system reform to reduce the population in prisons is likely to be unpopular. Additionally, some have claimed that since the early 20th century, there has been a resistance to accept that diseases transmit through the air due to the legacy of the discredited miasma theory of disease transmission ('diseases float through the air') and its replacement by germ theory ('person-to-person contact spread of disease'). In a historical analysis of disease transmission research, Jimenez *et al* claim that this historical resistance has informed controversies over whether COVID-19 is mainly transmitted by droplets or aerosols.[11]

The impacts of COVID-19 have raised questions about epidemic preparedness, forcing many to consider possibilities for postpandemic transformations and for rethinking our institutions and the standards they are held to. We contend such considerations must include carceral institutions, particularly as people who are incarcerated have been shown to be at increased risk for COVID-19 infection and death.[12] Accordingly, this paper makes a conceptual and empirical contribution towards rethinking standards on the size of prison cells. This is achieved by identifying additional constructs to be considered when conceiving cell size standards, and bringing together and reviewing in the one publication a variety of data specific to cell size standards around the world and available studies on COVID-19 transmission in prisons where prison crowding is considered in analyses.

This review aims to describe current international, regional, and national standards and guidelines on minimum cell size with a focus on cell spatial density levels—defined as accommodation cell floor area, measured in square feet/square metres, per person—and assess the evidence regarding the association between COVID-19 transmission in prisons and prison crowding measures. Recommendations are provided in accordance with the authors' deliberation regarding the review's outcomes. Instead of recommending a single, fixed minimum cell spatial density level as is the practice of many current guidelines, we propose a graded approach that consider resources for, and access to, healthcare, the physics of respiratory emissions and agent and host characteristics that all combine to determine transmission risk within prisons. Given that depriving persons of their freedom should not be exacerbated by current and future pandemics and epidemics as well as the likely resource burden that would be assigned to justice/correctional departments to increase physical separation between persons in cells, we underscore the importance of a shared approach across government departments for prison decarceration to reduce crowding, with healthcare, economic and social supports available to those released or diverted from prison as a consequence of decarceration.

METHOD

A scoping review was used. A scoping review is preferred where the purpose of the review is to identify knowledge gaps, scope and general findings of a body of literature, and clarify concepts. This is opposed to systematic reviews where risk and bias within studies are critically appraised and a quantitative synthesis of findings from individual studies is undertaken. For this to occur study designs and analyses need to be similar. A scoping review was selected due to the heterogeneity of literature types examined and COVID-19 study designs. A scoping review also provides more flexibility is collating and presenting information and findings. Drawing from Levac *et al*,[13] the scoping review was informed by a five-stage protocol. Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for Scoping Reviews (PRISMA-ScR) feature in this review (see online supplemental information for PRISMA-ScR checklist).[14]

Identifying the research question/objective

Informed by the research team's previous work on prison crowding[5] and through consultation with colleagues and key stakeholders, the following three objectives were developed:

1. Describe current international, regional and national guidelines on prison cell spatial density levels.
2. Describe studies examining the association between COVID-19 transmission and prison crowding.
3. Provide recommendations on prison cell spatial density standards in a (post)pandemic world.

Identifying relevant literature

PubMed, ProQuest, Informit, Criminal Justice Abstracts, Cochrane, Web of Science, Scopus, EMBASE, Google Scholar and Google were searched to November 2021 and updated at the time of manuscript writing to identify relevant peer-reviewed and grey literature. Separate literature searches were run for objectives one and two (see online supplemental file 1 for search strategies). Our search string for prison cell spatial density standards was not limited to the title or abstract of articles but included the whole body of text. Our search string for COVID-19 and prison crowding studies was limited to the title or abstract of articles (see online supplemental information for search strings). Individual articles were also searched for relevant references.

Selecting literature

Literature titles and study abstracts were reviewed for relevance and duplicates removed. Full-text reports and articles were then assessed for eligibility based on the following selection criteria. For objective 1, literature had to describe standards of prison accommodation or cell size/dimensions. Literature that referred to guidelines for short-term accommodation and settings that housed specific populations (eg, psychiatric and juvenile detention facilities) were excluded. For objective 2, studies were included if the study outcome was COVID-19 transmission/infection/incidence in a prison and included a crowding measure as an exposure variable (see table 1 in Simpson *et al*[5] for scope of prison crowding measures).

Charting the data

Data were extracted by one reviewer (SD) and cross-checked by another (PLS). The first section outlines international, regional and national standards on cell spatial density. Qualitative recommendations were also extracted in the absence of reported density measures. For most countries in which a quantitative standard was not available, data from the International Committee of the Red Cross (ICRC) Review of Space Accommodation Standards of Prison Cells 2014 was used.[15] The ICRC obtained this data through survey responses received from prison administrations supplemented with other publicly available information.[15] Some countries have no readily available data and were excluded from the review. The second section extracted data from COVID-19 transmission in prison studies and outlines study design, crowding measure used, an appraisal of the crowding measure, crowding measure relevance to spatial density and main findings.

Table 1 Recommended national standards for single, double and multiple-occupancy cell size per person

Nation/Jurisdiction	Single cell (total m^2)	Double cell (m^2 per person)	Multiple occupancy (m^2 per person)
Oceania			
Australia			
Australian Capital Territory[15]	8.9	5.35	
Victoria[49]	6.5	6.0	
New South Wales[50]	8.5	5.25	
New Zealand[15]	7.6		3.9
Fiji[15]	5.6		3.7
Africa			
Kenya[15]		3.7	
Senegal[15]		3.55	
Guinea[15]		2	
Malawi[15]		2–4	
Mauritius[15]		4.08	
South Africa[15]	5.5		3.5
North America			
Canada[15]	6.5		
USA[16]	5.57		
South America			
Chile[15]	6		
Guatemala[15]	11.52	6.98–7.46	
Europe			
Ireland[27]	7	4	
Switzerland[15]	16	8	7.3
Italy*[15]	9	7	
Liechtenstein*[15]	11.27		
Spain[15]	13		
Finland[15]	7	5	
Netherlands[15]	10		
Norway[15]	10		
Austria[15]	9.4		
Cyprus[15]	7	4	
Scotland[27]	7	4.5	
Slovakia[15]	3.5		
France[28]	9	5.5	4.67
England[29]	5.5	7.15	
Albania[15]	4		
Bulgaria[15]	4		
Croatia[15]	4		
Romania[15]	4		
Czech Republic[15]	4		
Moldova[15]	4		

Continued

Table 1 Continued

Nation/Jurisdiction	Single cell (total m²)	Double cell (m² per person)	Multiple occupancy (m² per person)
Azerbaijan[15]	4		
Turkey[15]	11.5–12.45		
Hungary[15]	6	3	
Poland*[15]	3		
Russia[15]	2.5		
Latvia[15]	9	2.5	
Estonia[15]	2.5		
Asia			
Japan[15]		2.5	
Korea[15]	2.4		
Thailand[15]		2.25	
Taiwan[15]		2	
India[15]	8.92		3.71
Pakistan[15]			1.25ˆ
Philippines[15]		4.7	
Hong Kong[15]	4.6		

*Does not include toilet/ensuite
ˆCell size for people on 'death row'

Patient and public involvement

Patients and the public were not involved in the review.

RESULTS

Following article identification, duplicate removal and screening, a total of 17 reports on standards (figure 1), and 6 COVID-19 and prison crowding studies (figure 2) were included.

Prison cell spatial density standards

International

International prison cell standards historically have tended to be qualitative to be generalisable to regions and countries that may vary in terms of socioeconomic, cultural and political factors, as well as government resources. The first international attempt that implicates prison spatial density as a health issue was recorded in the recommendations provided by the Geneva Convention in 1929 that stated that 'as regards dormitories, their total area, minimum cubic air space, fittings and bedding material, the conditions shall be the same as for the depot troops of the detaining Power.'[15] Around this same time, the SMR for the Treatment of Prisoners was first drafted, and in 1955 was revised by the First United Nations (UN) Congress on the Prevention of Crime and the Treatment of Offenders with Rule 10, stating 'all accommodation provided for the use of prisoners and in particular all sleeping accommodation shall meet all requirements of health, due regard being paid to climatic conditions and particularly to cubic content of air, minimum floor space, lighting, heating and ventilation' and that 'each prisoner shall occupy by night a cell or room by himself.'[16] During the revision consultation phase the UN Secretariat proposed adding a new rule: 'A floor space of 6 m^2 (65 ft^2) per incarcerated person and air content of 15 m^3 (530 ft^3) under normal ventilation must be considered as minimum requirements.'[16] However, the text was not included in the 1955 adopted SMR, or the 2015 revised SMR ('The Mandela Rules').

In 2004, the UN backed International Scientific and Professional Advisory Council (ISPAC) published standards in its Correctional Facilities Needs Assessment and Master Planning Manual, stating that 'each prisoner should have a designated sleeping and personal space of at least 3.5 square meters that provides for separation […] When one prisoner is confined alone in one cell or

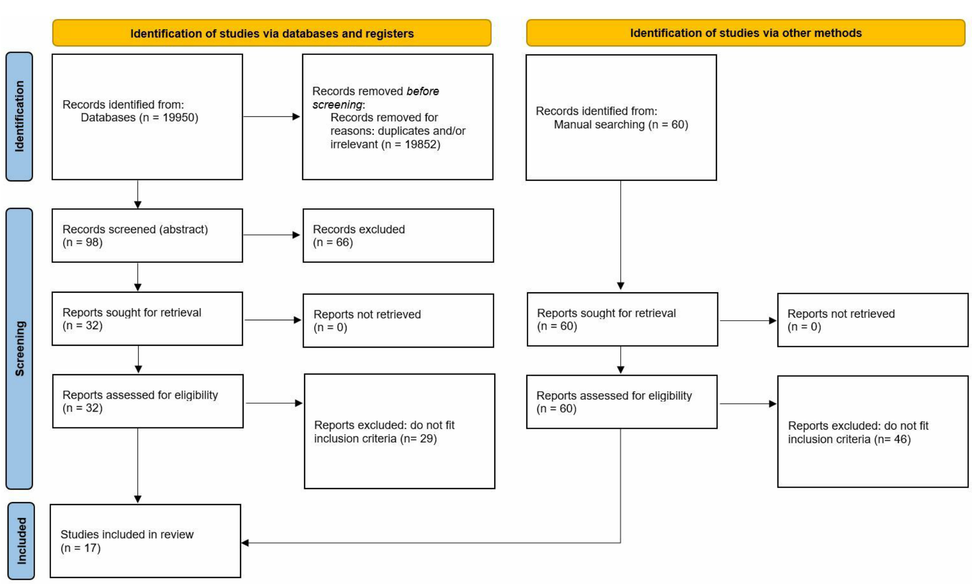

Figure 1 Flow diagram of article selection on prison cell spatial density standards.

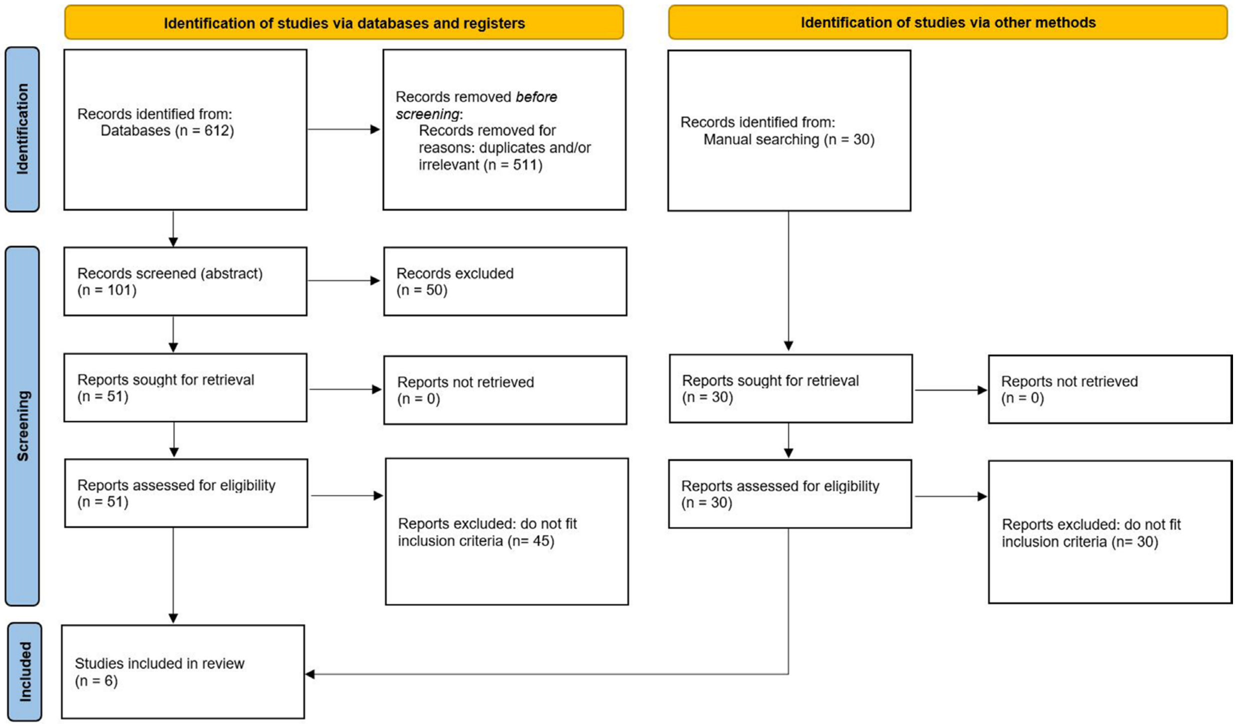

Figure 2 Flow diagram of article selection on COVID-19 and prison crowding studies.

room the room size should be a minimum of 4.5 square meters.'[17] These standards were also accepted by the UN Office on Drugs and Crime (UNODC) and the International Corrections and Prisons Association (ICPA).[15] The ICRC released the Water, Sanitation, Hygiene and Habitat in Prisons Handbook in 2013 recommending 3.4 m^2 per person in dormitories and 5.4 m^2 for single cells.[18]

Regional

In Africa, the Robben Island Guidelines adopted by the African Commission on Human and Peoples' Rights in 2002 uses a qualitative standard, reporting that 'states should take steps to ensure that the treatment of all persons deprived of their liberty are in conformity with international standards guided by the UN SMR.'[19] Similarly, in Latin America, the Inter-American Commission and the Court on Human Rights stipulates standards in qualitative terms such that each incarcerated person 'shall have adequate floor space, daily exposure to natural light, appropriate ventilation and heating'.[20]

The Council of Europe's European Prison Rules (EPR), produced in 1973 and revised in 2020, adopts the same qualitative standard as the SMR. Specific quantifiable minimum requirements the EPR states 'shall be set in national law' and that 'national law shall provide mechanisms for ensuring that these minimum requirements are not breached by the overcrowding of prisons.'[21] However, in 2015 the Council of Europe's Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT) released quantified standards in response to European member states, detention monitoring bodies established under the UN Optional Protocol to the Convention against Torture, domestic courts, and NGOs. CPT standards include 4 m^2 per person for multiple-occupancy cells (of two to four persons) and 6 m^2 for single cells.[22] The CPT notes that 'the 4 m² per prisoner standard may still lead to cramped conditions when it comes to cells for a low number of inmates' and as a result has decided to promote a 'desirable standard regarding multiple occupancy cells of up to four inmates by adding 4 m² per additional inmate to the minimum living space of 6 m² of living space for a single-occupancy cell'.[22]

The Standard Guidelines for Prison Facilities in Australia and New Zealand in 1990 include both qualitative and quantitative standards. The qualitative recommendations mirror those of the SMR, where accommodation is to meet all 'requirements of health' and be preferentially single cells.[23] This is supplemented with a minimum standard of 7.5 m^2 for single cells and 11.5 m^2 for double cells (ie, 5.75 m^2 per person) without sanitary facilities and an additional 4 m^2 per person in dormitories with no more than four persons.[23]

National

Spatial density recommendations vary significantly between nations (table 1).[15 24–29] For single cells, the lowest reported standard is 2.4 m^2 in Korea and the highest reported standard is 16 m^2 in Switzerland. For multiple-occupancy cells, the lowest space allocation per person is recorded at 1.25 m^2 in Pakistan and the highest is 10 m^2 in Netherlands. Some of the guidelines also represent minimum dimensions for new prison constructions and may not reflect currently enforced standards or practices in response to prison crowding. Some measurements also incorporate other spaces in their calculation of spatial

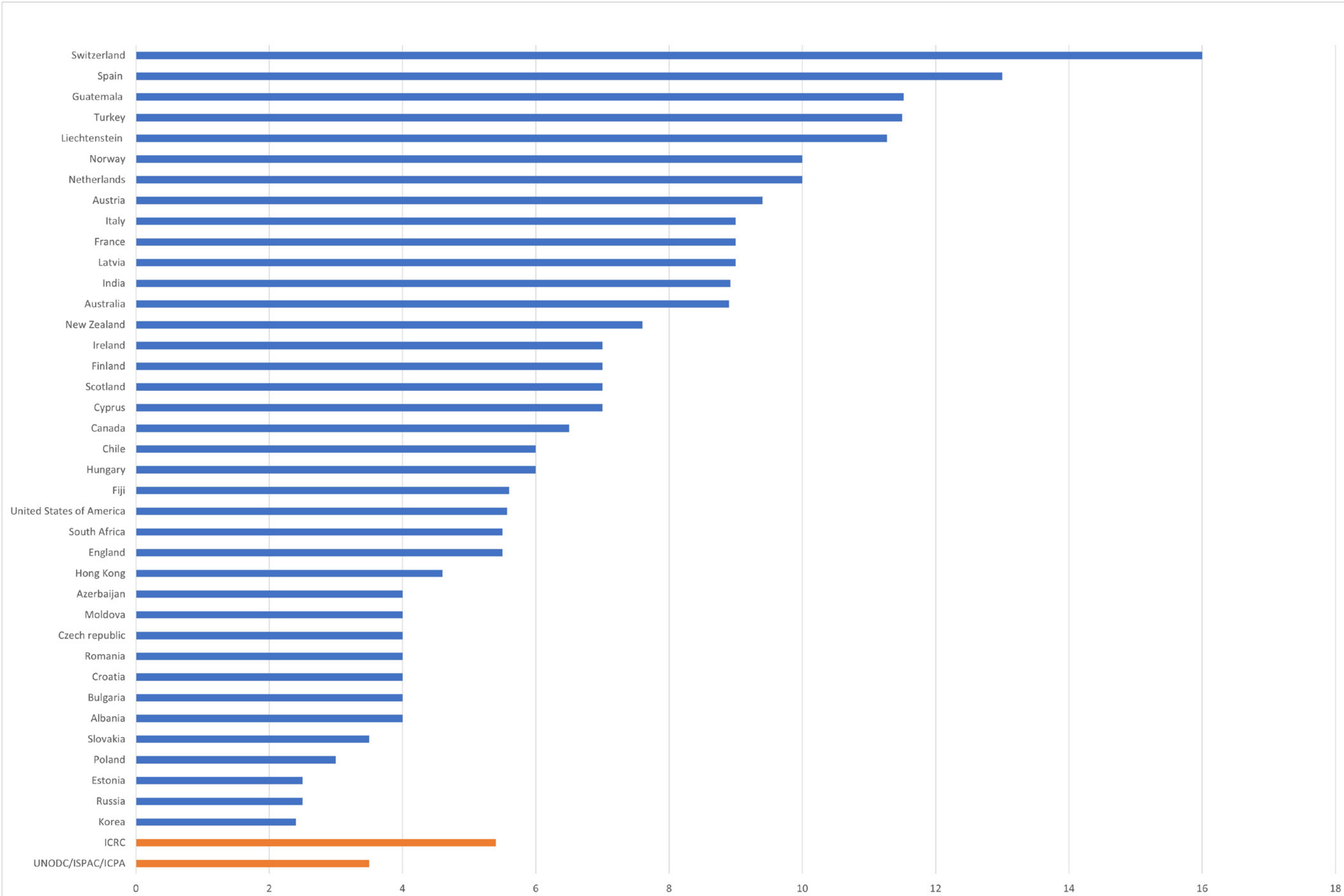

Figure 3 Recommended floor area size (m^2) for single occupancy cells by country against international standards. ICPA, International Corrections and Prisons Association; ICRC, International Committee of the Red Cross; ISPAC, International Scientific and Professional Advisory Council; UNODC, UN Office on Drugs and Crime.

density, such as sanitary facilities. Figure 3 and figure 4 compare national single-cell and multiple-occupancy spatial density recommendations against international recommendations. For single occupancy and multiple occupancy cells respectively, 65.8% and 68.4% of countries meet ICRC standards, and 68.4% of countries meet standards of both single and multiple occupancy guidelines recommended by the organisations UNODC, ISPAC and ICPA.

Evidence reporting links between COVID-19 transmission and prison crowding

The characteristics of included studies are presented in table 2.[2 30–34] A prospective cohort investigation that conducted SARS-CoV-2 testing for incarcerated persons in six dormitories in Louisiana in the USA showed that dormitory E, which had the lowest occupancy rate of 32%, had the lowest cumulative incidence of positive SARS-CoV-2 PCR tests (57%). Conversely, dormitory F was near full capacity at 90% and had the highest cumulative testing incidence of 89%.[30] Similarly, in a longitudinal ecological study conducted in Massachusetts' prisons in the United States of America (USA), an increase in the incarcerated population as a function of the prison design capacity was associated with higher COVID-19 transmission rates. The authors report that 'for every 10% increase in prisoner population (as a percentage of prison design capacity), there was a 14% increased risk of COVID-19'.[2] Further, the study reported that 'compared with those weeks when prisons maintained an incarcerated population below 70% of design capacity, prisons operating between 70% and 100% and prisons operating at more than 100% of their design capacity had approximately 3-fold and 5-fold higher incidence rates of COVID-19, respectively.'[2] Overall, it was reported that 'COVID-19 incidence was significantly higher in prisons where the incarcerated population exceeded the prison's design capacity (incidence rate ratio per 10-percentage-point difference, 1.14; 95% CI 1.03 to 1.27).'[2]

Using a stochastic dynamic transmission model of COVID-19 for a large US urban jail, with a basic reproduction rate (R_0) of 8.44 (95% CI 5.00 to 13.10), it was estimated that decarceration efforts would reduce the R_0 to 3.64 (95% CI 2.43 to 5.11). This reproduction rate is based on a decrease of 1.41% of the total jail population each day through 'a combination of measures which included a marked decrease in new detentions given changes in court and judicial system procedures and large community organised bail outs.'[31] This occurs after

 Dahiya S, *et al. BMJ Open* 2023;**13**:e069952. doi:10.1136/bmjopen-2022-069952

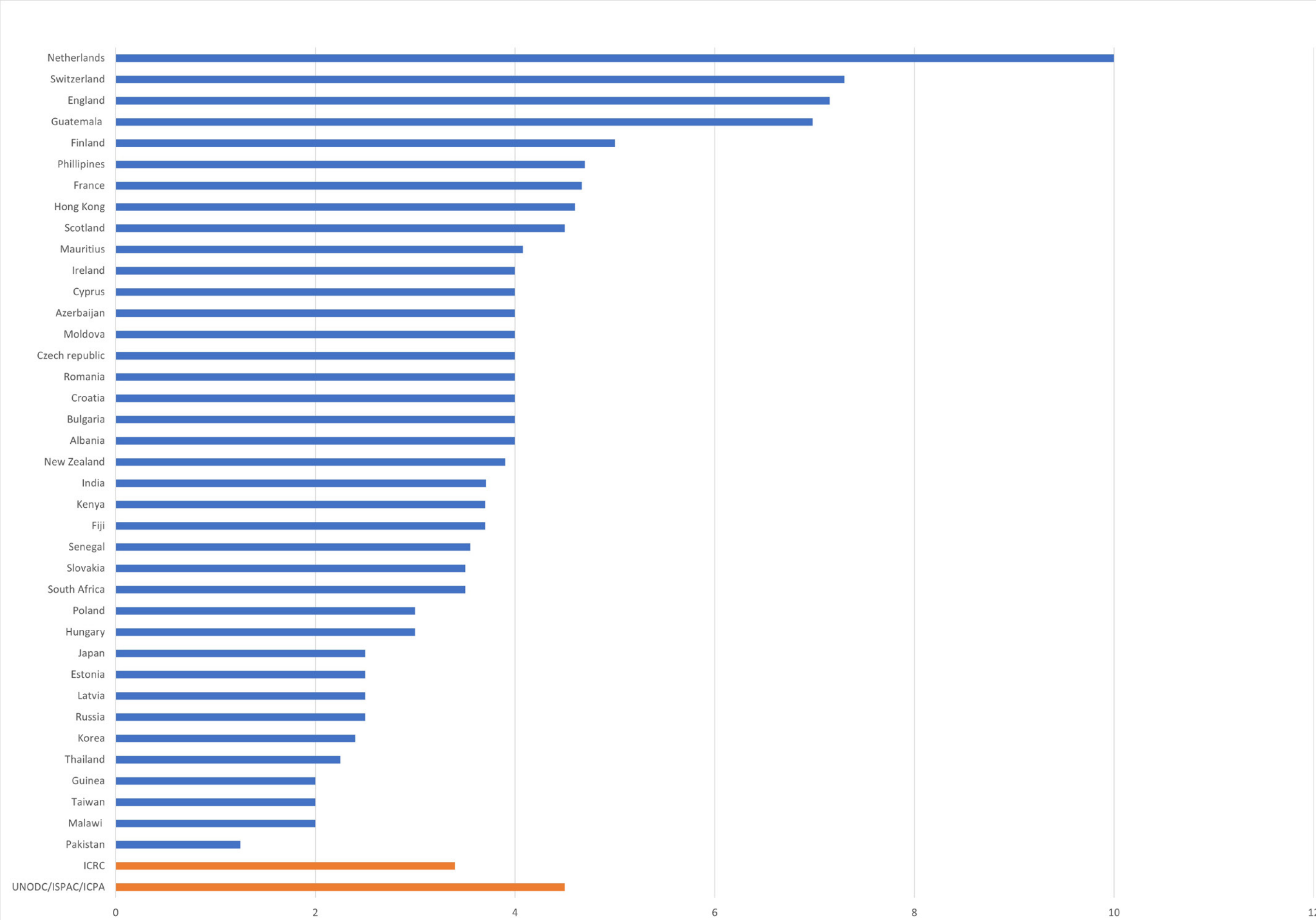

Figure 4 Recommended floor area size (m^2) for multiple occupancy cells by country against international standards. ICPA, International Corrections and Prisons Association; ICRC, International Committee of the Red Cross; ISPAC, International Scientific and Professional Advisory Council; UNODC, UN Office on Drugs and Crime.

phase 1, which includes a range of baseline strategies including basic screening for influenza-like symptoms, 1-week quarantine for new detainees, sanitation procedures and suspension of large gatherings and in-person visitation.[31] A cohort study further analysed the impact of decarceration, estimating that an '80% reduction in US jail populations would have been associated with a 2% reduction in daily COVID-19 case growth rates' within the county and 'when controlling for anticontagion policies, mass release events were associated with a 3.1% (95% CI 1.9% to 4.3%) decrease in COVID-19 growth rates 2 weeks later and a 5.3% (95% CI 3.5% to 14.1%) decrease in daily jail population.'[32]

In an observational study in the California state prison system, it was determined that 'rates of COVID-19 infection among residents of dormitories (≥3 occupants) were more than double those among residents of cells (adjusted HR 2.51; 95% CI 2.25 to 2.80)' and that 'these differences represent a cumulative risk of infection that is 28.6 percentage points higher (95% CI 16.7% to 30.6%; 62.1% vs 33.4%)' for persons living in dormitory accommodation.[33] Another observational study considered the epidemiology of COVID-19 in Federal Bureau of Prisons staff and found that 'working in dorm-style housing and in detention centres were strong risk factors, whereas cell-based housing was protective.'[34] Compared with employment in a stand-alone medium security facility (cell-based housing), working in a stand-alone low security facility (dormitory-style housing) had an adjusted OR of 4.3 (95% CI 3.3 to 5.6) whereas working in a stand-alone high security facility (cell-based housing) had an adjusted OR of 0.3 (95% CI 0.1 to 0.7).[34]

DISCUSSION

This scoping review found that standards for prison cell spatial density from international and regional bodies were mostly qualitative in nature, with two quantifiable international standards located (3.4 m^2 and 3.5 m^2 per person for multiple occupancy cells), and two quantifiable regional standards located (4 m^2 per person (Europe) and 5.75 m^2 or 4 m^2 per person (Australia and New Zealand)). Country-based standards varied substantially, ranging from 1.25 m^2 per person (Pakistan) to 10 m^2 per person (Netherlands). Some regions and nations had no available guidelines or data to extrapolate from.

Table 2 Characteristics of COVID-19 and prison crowding studies

Study	Study location	Sample size	Study design	Crowding measure	Appraisal of crowding measure ('poor', 'fair' or 'good')	Crowding measure relevance to cell spatial density	Main findings
Leibowitz *et al*[2]	USA	6876	Longitudinal ecological study	1. Prison capacity: Prison population divided by prison design capacity and 2. Cell social density: Percentage of incarcerated persons housed in single-cells	1. Poor to fair. Some risk of exposure misclassification as assessment of design capacity by prison authorities may be biased. 2. Good. While social density measures obscure the extent physical distancing can occur between persons, single cells are not subject to this concern.	1. An increase in prison population may increase cell spatial density, however, is a less specific measure of individual space allocation. 2. Percentage not in single-cells indicates a higher level of spatial density but exact dimensions not reported.	1. COVID-19 incidence was significantly higher in prisons at over capacity. 2. COVID-19 incidence was lower in prisons where a higher proportion of people were in single-cells.
Wallace *et al*[30]	USA	143	Prospective cohort study	Dormitory capacity: Number in dormitory divided by dormitory design capacity	Fair. Low to medium risk of exposure misclassification as assessment of design capacity by prison authorities may be biased.	An increase in dormitory capacity increases spatial density.	Lowest cumulative incidence occurred in dormitory E, which had lowest occupancy.
Malloy *et al*[31]	USA	Several thousand staff and incarcerated individuals	Stochastic dynamic transmission model	1. Prison capacity: Total jail population and, 2. Cell social density: Percentage of incarcerated persons housed in single-cell units	1. Poor. Medium to high risk of exposure misclassification. Increase in jail population does not indicate the extent of physical distancing. 2. Good. While social density measures obscure the extent physical distancing can occur between persons, single cells are not subject to this concern.	1. An increase in prison population may increase cell spatial density, however, is a less specific measure of individual space allocation. 2. Percentage not in single-cells indicates a higher level of spatial density but exact dimensions not reported.	Basic reproduction no (R0) for COVID-19 from outbreak to decarceration phase decreased from 8.44 to 3.64 and decreased further to 1.72 when higher proportion of people were housed in single cells. Following these interventions R0=0.58 when asymptomatic testing was introduced.
Reinhart and Chen[32]	USA	1605 counties with a mean jail population of 283.38 (SD 657.78)	Longitudinal ecological study	Prison capacity: Daily jail population	Poor. Medium to high risk of exposure misclassification. Increase in one jail may not have the same crowding effect as an increase in another jail.	An increase in prison population may increase cell spatial density, however, is a less specific measure of individual space allocation.	80% reduction in jail populations associated with a 2.0% reduction in daily COVID-19 case growth rates. Decarceration was associated with eight times larger reductions in COVID-19 growth rates in counties with above-median population density.
Chin *et al*[33]	USA	96 623	Prospective cohort study	Cell social density: Persons residing in 'cells' (1–2 occupants) or 'dormitories' (≥3 occupants)	Fair. Low to medium risk of exposure misclassification. Space per person in a dormitory may be higher than that of a cell.	Social density is correlated with spatial density, provided that space per person is not higher in a dormitory than a cell.	Rates of COVID-19 infection among people in dormitories were more than double those among people in cells.
Toblin *et al*[34]	USA	37 640	Retrospective cohort study	Cell social density: Number of persons per dormitory vs cell)	Fair. Low to medium risk of exposure misclassification. Space per person in a dormitory may be higher than that of a cell.	Social density is correlated with spatial density, provided that space per person is not higher in a dormitory than a cell.	Staff working in dormitories were strong risk factors, whereas working in cells was protective; these effects were erased if staff mixed between cell types.

Rationales for standards do not appear to be evidence-based in many cases and are rarely publicly available for review and comment. Infectious disease imperatives, and specifically, diseases transmitted via respiratory emissions, were largely absent from the discourse on cell size standards. Our review of COVID-19 transmission and prison studies found consistent evidence that prison crowding, while measured variously, is associated with COVID-19 transmission. This emergent evidence directs us to reconsider prison accommodation standards and consider strategies that include but extend beyond a focus on cell size standards alone.

Prison decarceration

In line with our findings, we recommend decarceration approaches as a primary strategy for managing the public health burden associated with respiratory infectious disease outbreaks in prisons. We refer to decarceration here as a permanent measure at a policy level that reduces the incarcerated population, incorporating an informed and strategic approach with due consideration of community safety. While beyond the scope of this review, future social science research in this field is needed to outline potential structural and policy recommendations. One area of research comes from proposals within prison abolition movements. Although the positions of academics and advocates within the movement differ in terms of their philosophical and political backgrounds and demands, one shared idea is for the replacement of current criminal legal practices by restorative and transformative justice to radically reduce incarcerated population levels.[35]

The alleviation of crowding is likely to preserve healthcare resources associated with incarceration and COVID-19 transmission, particularly in countries and communities where these resources are already likely to be strained.[3–5] Importantly, while political rhetoric directs blame on early release from prisons for crime increases, no current evidence supports this claim.[36] An American Civil Liberties Union study reported that by October 2020, the jail population of the US state of Colorado decreased by 46% with no associated increase in state-wide crime rates and pretrial misconduct remained low.[36]

Racial and ethnic minority communities have proportionally more to gain from decarceration due to the over-representation of these groups in incarcerated populations and the racial inequalities of COVID-19 health outcomes. A US study found that the COVID-19 mortality rate in Texas prisons was significantly higher in black and Hispanic populations when compared with White populations. This finding was attributed partly to the fact that facilities with larger non-white populations tend to have greater population density.[37]

Vaccinations and non-pharmaceutical interventions (NPIs) should be provided to incarcerated persons. However, it is unlikely that these will be sufficient in managing disease outbreaks without complementary efforts aimed at depopulation.[38] The transmission-dynamic stochastic microsimulation study found that if 'a viral variant is introduced into a prison that has resumed pre-2020 contact levels, has moderate vaccine coverage (ranging from 36% to 76% among residents, dependent on age, with 40% coverage for staff), and has no baseline immunity, 23%–74% of residents are expected to be infected over 200 days.'[39] The study notes that high vaccination coverage (90%) with the ongoing implementation of NPIs are likely to decrease cumulative infections to 2%–54%.[39] However, a recent study that modelled the protective outcomes of a COVID-19 vaccine found that even a highly effective vaccine may be insufficient in managing an outbreak if the vaccination pace is slow and the virus R_0 at the time is high.[40] Prison systems are often poorly resourced and unlikely to maintain high levels of vaccination, sanitation and NPIs due to shortages in personal protective equipment (PPE), cleaning and hygiene supplies.[41 42] Further, testing for infectious diseases in prisons has been reported to occur at lower rates than the general community and often occurs as a reactive management strategy rather than as a preventative one.[43] These healthcare delivery factors are all integral to the spread of infectious disease and should be considered in conjunction with spatial density metrics to inform decarceration measures on an individual prison basis.

Beyond a cell spatial density focus

In jurisdictions reluctant to implement decarceration strategies, we recommend an approach to standards that move beyond a sole focus on cell spatial density levels. This approach will require consideration of three key factors that when combined increases risk of airborne infectious disease transmission in prisons: cell spatial density, ventilation, and a prison's healthcare delivery. There is increasing awareness that 1–2 m distancing rules applied to the COVID-19 pandemic are not compatible with the physics of respiratory emissions and provide an oversimplification based on outdated science and on past viruses.[44 45] Force of respiratory emission, ventilation and exposure time factors suggest larger cell sizes are warranted. Shouting, coughing and sneezing 'generate warm, moist, high momentum gas clouds of exhaled air containing respiratory droplets' that move 'faster than typical background air ventilation flows' and can extend up to 7–8 m.[45]

Consistent with Jones *et al*,[45] we contend that spatial density standards would be more effective if they reflected graded levels of risk. Accordingly, figure 5 presents graded levels of risk based on cell spatial density, ventilation and healthcare administration regarding vaccine and treatment availability, adequate resourcing of NPIs and availability of health staff. Where appropriate, we recommend accommodation in single-cells in accordance with the evidence that dormitory-style accommodation is a risk factor for increased COVID-19 transmission. Note, this does not refer to solitary confinement or the cessation of out-of-cell activities. Further, provided cells

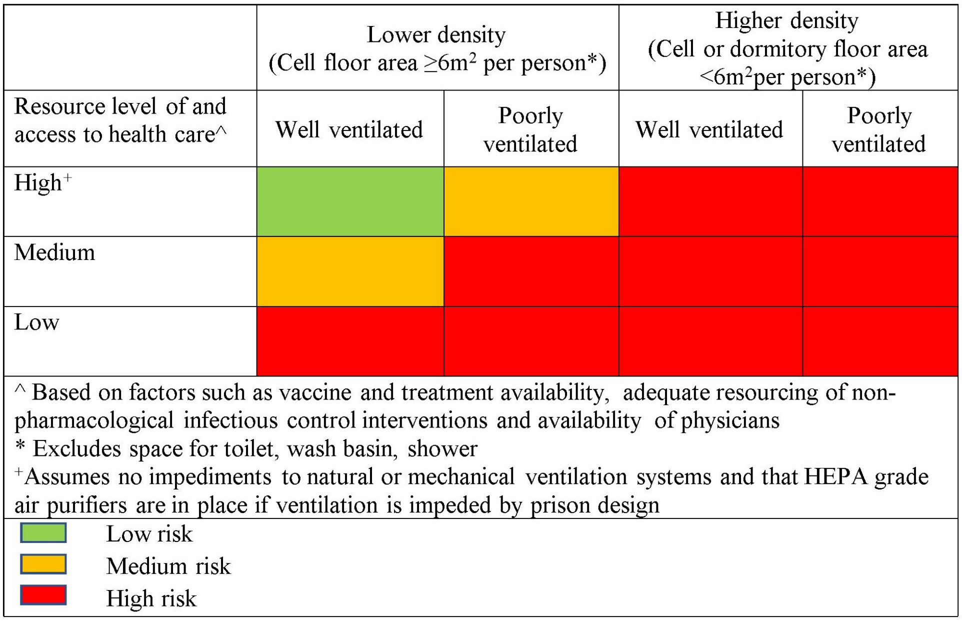

Figure 5 Graded levels of airborne infectious disease risk for incarcerated people in different prison cell spatial density levels, ventilation levels and healthcare systems. HEPA, high-efficiency particulate air.

are well ventilated and healthcare delivery is adequate, we recommend, maintaining the minimum spatial density of 6 m^2 per person in cells (excluding sanitary facilities) in the case where single celling may not be an option due to prison design and crowding. A cell that is well ventilated is characterised by an intentional introduction of clean air into a cell as the stale air is removed. Ventilation rate is measured by the absolute amount of inflow air per unit time (litre per second or l/s, cubic metre per hour or m^3/hour) or the air-change rate as the relative amount of inflow air per hour. Ventilation can be facilitated by natural and mechanical systems. Although natural and mechanical systems can be equally effective, mechanical ventilation may be costly and natural ventilation only works when natural forces are available and enabled, for example, a degree of wind must exist and windows and exhaust apertures must be open.[46] Cold weather also presents a challenge where a trade-off between air quality and a comfortable ambient temperature is made. Where ventilation systems cannot be improved due to design constraints, high-efficiency particulate air grade air purifiers that are appropriately sized for the space should be considered.[47] Determining minimum ventilation rate requirements, will require further investigation and research.

Prisons that exhibit conditions graded medium and high risk should initiative decarceration strategies. Deciding what constitutes low, medium and high resource level of health care and determining the extent of decarceration for each risk category will require further investigation and research. While an individual's immunodeficiency level and underlying health conditions are also important factors for transmission, research consistently shows that incarcerated populations are relatively homogeneous in terms of poorer health than the wider community. As such, this is an assumed constant in our graded levels of risk. Decarceration as a planned response to medium to high-risk grading should occur in a preventative way with investments in sustainable long-term health, social and economic supports including housing in place to prevent overloading existing levels of community resources with the sudden release of incarcerated persons that occurs when decarceration is employed as a reactive strategy to growing outbreaks.[48]

To appreciate the outcomes of the review and subsequent discussions and recommendations the following limitations should be considered. First, quantitative prison cell spatial density standards were not located for many countries. It is unclear if this is because quantitative standards do exist and are not publicly available or that they simply do not exist and perhaps rely on standards that are qualitative in nature. Of the 190+ countries that currently exist, we located quantitative cell spatial density standards for only 48 countries. Second, the review of studies examining associations between prison crowding and COVID-19 transmission in prisons was limited by the small number (n=6) of studies located. Additionally, all studies were confined the USA. Thus, caution may be warranted in terms of generalisability and applicability of the findings to other correctional systems outside of the USA. However, a previous systematic review we conducted before the COVID-19 pandemic found that the global body of evidence provides consistent support for an association between prison cell special density and infectious and communicable diseases.[5]

CONCLUSION

The impacts of COVID-19 have forced many to consider possibilities for postpandemic transformations and for rethinking carceral institutions and the standards they are held to. Considerable research is needed to provide a better understanding on what safe living conditions in prisons during an airborne pandemic entail. This study provides a conceptual and empirical contribution to addressing this need by identifying additional constructs to be considered when conceiving cell size standards, and bringing together and reviewing a variety of data specific to cell size standards and available studies on COVID-19 transmission in prisons where prison crowding is considered in analyses.

Our review showed that, globally, prison cell spatial density standards vary substantially and are justified with little or absent consideration to airborne infectious disease outbreaks in prisons. Informed by our assessment that there is consistent evidence on the association between crowding and COVID-19 transmission in prisons, combined with consideration of the physics of respiratory emissions, we recommend an approach that moves beyond a sole focus on cell size. We contend that ensuring physical distancing can occur between persons within a prison and prison cell is the most effective way to manage the risk of current and future airborne infectious diseases in prisons. To achieve this, we recommend prioritising decarceration strategies. Additional priorities include single-celling or maintaining a minimal spatial density standard of 6 m^2 per person in multiple occupancy cells (excluding sanitary facilities) where single celling is not possible, ensuring good ventilation and air quality, and ensuring that healthcare access and resources in prisons are adequate. If these conditions cannot be met, then prison decarceration strategies become more important and should take priority over the construction of new prisons.

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REFERENCES

1 Howard J. *State of the prisons in england and wales (first published 1777)*. United Kingdom: Patterson Smith, 1973.
2 Leibowitz AI, Siedner MJ, Tsai AC, *et al*. Association between prison crowding and COVID-19 incidence rates in Massachusetts prisons, April 2020-January 2021. *JAMA Intern Med* 2021;181:1315–21.
3 National Academies of Sciences E, Medicine. *Decarcerating correctional facilities during COVID-19: advancing health, equity, and safety*. Washington, DC: The National Academies Press, 2020.
4 Simpson PL, Butler TG. Covid-19, prison crowding, and release policies. *BMJ* 2020;369:m1551.
5 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.
6 Friedman B. Toward a critical race theory of prison order in the wake of COVID-19 and its afterlives: when disaster collides with institutional death by design. *Sociological Perspectives* 2021;64:689–705.
7 Anthony T, Chartrand V. States of prison abolition: COVID-19 and anti-colonial and anti-racist organising. *Justice, Power and Resistance* 2022;5:46–66.
8 Møller L, Stöver H, Jürgens R, *et al*. *Health in prisons: a WHO guide to the essentials in prison health*. Copenhagen: World Health Organisation, 2007.
9 Pierce J. Making the mandela rules: evidence, expertise, and politics in the development of soft law international prison standards. *Queen's Law Journal* 2018;43:263–95.
10 United Nations Office on Drugs and Crime. *Contributions for the revision of the United Nations standard minimum rules for the treatment of prisoners. Open-ended intergovernmental expert group on the standard minimum rules for the treatment of prisoners UNODC/CCPCJ/EG.6/2014/NGO.3*. Vienna, Austria, 2014.
11 Jimenez JL, Marr LC, Randall K, *et al*. What were the historical reasons for the resistance to recognizing airborne transmission during the COVID-19 pandemic? *Indoor Air* 2022;32:e13070.
12 Saloner B, Parish K, Ward JA, *et al*. COVID-19 cases and deaths in federal and state prisons. *JAMA* 2020;324:602–3.
13 Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:69.
14 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
15 International Committee if the Red Cross. Review of space accommodation standards in prison cells; 2014. Water & Habitat – PRISONS - N°6.
16 United Nations. *Standard minimum rules for the treatment of prisoners*. Geneva, 1955.
17 Goble RT. Correctional facilities needs assessment and master planning: a fast-track guide for officials in developing nations: planning manual. In: *International Scientific and Professional Advisory Council of the United Nations Crime Prevention and Criminal Justice Program and the International Corrections and Prisons Association*. 2004.
18 Nembrini PG. *Water, sanitation, hygiene and habitat in prisons*. Geneva: International Committee of the Red Cross, 2013.
19 Niyizurugero J-B, Lessène P. *Robben island guidelines for the prohibition and prevention of torture in Africa*. Geneva: Association for the Prevention of Torture (APT), 2008.
20 Inter-American Commission on Human Rights Organization of American States. Revision of the united nations standard minimum rules for the treatment of prisoners; 2014.
21 Council of Europe Committee of Ministers. The european prison rules; 1987.

22 European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT). *Living space per prisoner in prison establishments: CPT standards*. Strasbourg: Council of Europe, 2015.
23 Victorian Office of Corrections. *Standard guidelines for prison facilities in Australia and New Zealand*. 1990.
24 Correctional Service Canada. Inmate accommodation. 2017. Available: https://www.csc-scc.gc.ca/lois-et-reglements/550-cd-eng.shtml
25 American Correctional Association. *Core jail standards*. Virginia: American Correctional Association, 2010.
26 Reilly M. In: Ootlo P, ed. *The Irish Prison Population - an examination of duties and obligations owed to prisoners*. Count Tipperary Inspector of Prisons, 2010.
27 Silvestri A. *Prison conditions in the united kingdom*. Rome: European Prison Observatory, 2013.
28 Crétenot M, Liaras B. *Prison conditions in france*. Rome: European Prison Observatory, 2013.
29 Louky N. *Prison rules: A working guide*. London: Prison Reform Trust, 2000.
30 Wallace M, James AE, Silver R, *et al*. Rapid transmission of severe acute respiratory syndrome coronavirus 2 in detention facility, Louisiana, USA, May-June, 2020. *Emerg Infect Dis* 2021;27:421–9.
31 Malloy GSP, Puglisi L, Brandeau ML, *et al*. Effectiveness of interventions to reduce COVID-19 transmission in a large urban jail: a model-based analysis. *BMJ Open* 2021;11:e042898.
32 Reinhart E, Chen DL. Association of jail decarceration and anticontagion policies with COVID-19 case growth rates in US counties. *JAMA Netw Open* 2021;4:e2123405.
33 Chin ET, Ryckman T, Prince L, *et al*. COVID-19 in the California state prison system: an observational study of decarceration, ongoing risks, and risk factors. *J Gen Intern Med* 2021;36:3096–102.
34 Toblin RL, Cohen SI, Hagan LM. SARS-CoV-2 infection among correctional staff in the federal Bureau of prisons. *Am J Public Health* 2021;111:1164–7.
35 Pont J, Enggist S, Stöver H, *et al*. COVID-19–The case for rethinking health and human rights in prisons. *Am J Public Health* 2021;111:1081–5.
36 American Civil Liberties Union Colorado. *COVID-19 jail depopulation in colorado*. Colorado: American Civil Liberties Union Colorado, 2020.
37 Marquez N, Moreno D, Klonsky A, *et al*. Racial and ethnic inequalities in COVID-19 mortality within carceral settings: an analysis of texas prisons. *Health Aff (Millwood)* 2022;41:1626–34.
38 Simpson PL, Butler T, MacIntyre R, *et al*. *Updated report on the impact of the COVID-19 virus on the new south wales prisoner population UNSW*. Sydney: School of Population Health, Faculty of Medicine, 2021.
39 Ryckman T, Chin ET, Prince L, *et al*. Outbreaks of COVID-19 variants in US prisons: a mathematical modelling analysis of vaccination and reopening policies. *Lancet Public Health* 2021;6:e760–70.
40 Paltiel AD, Schwartz JL, Zheng A, *et al*. Clinical outcomes of a COVID-19 vaccine: implementation over efficacy. *Health Aff (Millwood)* 2021;40:42–52.
41 Nelson B, Kaminsky DB. A COVID-19 crisis in US jails and prisons. *Cancer Cytopathol* 2020;128:513–4.
42 Mekonnen B, Hailemariam S, Ejigu A, *et al*. Preparedness and readiness against COVID-19 pandemic in prison institutions and detention centers in Southwest Ethiopia. *Int J Gen Med* 2021;14:337–46.
43 Blair A, Parnia A, Siddiqi A. A time-series analysis of testing and COVID-19 outbreaks in Canadian federal prisons to inform prevention and surveillance efforts. *Can Commun Dis Rep* 2021;47:66–76.
44 Randall K, Ewing ET, Marr LC, *et al*. How did we get here: what are droplets and aerosols and how far do they go? A historical perspective on the transmission of respiratory infectious diseases. *Interface Focus* 2021;11:20210049.
45 Jones NR, Qureshi ZU, Temple RJ, *et al*. Two metres or one: what is the evidence for physical distancing in COVID-19? *BMJ* 2020;370:m3223.
46 World Health Organization. Roadmap to improve and ensure good indoor ventilation in the context of COVID-19. Licence: CC BY-NC-SA 3.0 IGO. World Health Organization Geneva; 2021.
47 Wang CC, Prather KA, Sznitman J, *et al*. Airborne transmission of respiratory viruses. *Science* 2021;373:eabd9149.
48 Natoli LJ, Vu KL, Sukhija-Cohen AC, *et al*. Incarceration and COVID-19: recommendations to curb COVID-19 disease transmission in prison facilities and surrounding communities. *Int J Environ Res Public Health* 2021;18:9790.
49 Water, sanitation, hygiene, and habitat in prisons: supplementary guidance. Geneva International Committee for the Red Cross; 2012.
50 Rafter F. Letter of responses to questions taken on notice before the budget estimates committee 2018-10: counter terrorism, corrections and veteran affairs, 4 September 2018. New South Wales Inspector of Custodial Services, 2018 Available: https://www.parliament.nsw.gov.au/lcdocs/other/11818/Answers%20to%20questions%20on%20notice%20-%20Inspector.pdf