COVID-19 Inmate Risk Appraisal (CIRA): Development and validation of a screening tool to assess COVID-19 vulnerability in prisons

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Abstract

Objectives. To develop and validate a screening tool designed to identify detained people at increased risk for COVID-19 mortality, the COVID-19 Inmate Risk Appraisal (CIRA).

Design. Cross-sectional study with a representative sample (development) and a case-control sample (validation).

Setting. The two largest Swiss prisons.

Participants. (1) Development sample: all male persons detained in Pöschwies, Zurich (*n*=365); (2) Validation sample: case-control sample of male persons detained in Champ-Dollon, Geneva (*n*=192, matching 1:3 for participants at risk for severe course of COVID-19 and participants without risk factors).

Main outcome measures. The CIRA combined seven risk factors identified by the World Health Organization and the Swiss Federal Office of Public Health as prognosis of severe COVID-19 to derive an absolute risk increase in mortality rate: Age ≥60, cardiovascular disease, diabetes, hypertension, chronic respiratory disease, immunodeficiency, and cancer.

Results. Based on the development sample, we proposed a three-level classification: average (<3.7), elevated (3.7-5.7), and high (>5.7) risk. In the validation sample, the CIRA identified all individuals considered vulnerable by national recommendations (having at least one risk factor). The category "elevated risk" maximized sensitivity (1) and specificity (.97). The CIRA had even higher capacity in discriminating vulnerable individuals according to clinical evaluation (a four-level risk categorization based on a consensus of medical staff). The category "elevated risk" maximized sensitivity and specificity (both 1). When considering the individuals classified as extremely high risk by medical staff, the category "high risk" had a high discriminatory capacity (sensitivity=.89, specificity=.97).

Conclusions. The CIRA scores have a high discriminative ability and will be important in custodial settings to support decisions and prioritize actions using a standardized valid assessment method. However, as knowledge on risk factors for COVID-19 mortality is still limited, the CIRA should be considered preliminary. Underlying data will be updated regularly on the website www.prison-research.com, where the CIRA algorithm is freely available.

Summary Boxes

What is already known on this topic: Prisons are environments characterized by unsanitary conditions, insufficient provision of healthcare, and promiscuity. All these factors can favor the spread of the COVID-19.

What this study adds: Our study proposed a standardized screening tool to identify detained people at increased risk for COVID-19 mortality. The COVID-19 Inmate Risk Appraisal (CIRA) appeared as a valid

tool and should be used in custodial settings to support decisions and prioritize actions to protect people living in detention.

1. Introduction

The current situation related to SARS-CoV-2 and its associated disease (COVID-19) poses critical challenges in prison settings.[1] Prisons are environments characterized by unsanitary conditions, insufficient provision of healthcare, and promiscuity.[2 3] All these factors can favor the spread of the disease.[4] Protecting persons living in prison from infection is a state responsibility and, therefore, public health guidance for prison authorities and healthcare practitioners is crucial.

One way to protect detained persons is through the early identification of those at increased mortality risk from COVID-19 and taking measures to prevent initial infection. The World Health Organization (WHO)[5] and the Swiss Federal Office of Public Health (FOPH)[6] suggest that older age, cancer, cardiovascular disease, chronic respiratory diseases, immunodeficiency, diabetes, and hypertension are risk factors for becoming severely ill after SARS-CoV-2 infection. The relevance of these risk factors has been supported in recent meta-analyses[7-11] and primary empirical studies from different countries including China,[12] the United States,[13] Italy,[14] and Switzerland.[15] However, there is no available tool to quantify prisoners' COVID-19 mortality risk and classify them into risk categories.

To address this gap, the present study used data from the two largest prisons in Switzerland to (1) develop a screening tool – named the COVID-19 Inmate Risk Appraisal (CIRA) – to identify prisoners at increased mortality risk and to classify them in risk categories, and (2) test its validity when compared to national recommendations and clinical evaluations of COVID-19 vulnerability. CIRA is important for custodial settings to support prison managers and staff in prioritizing cases and courses of action (e.g., testing, separation) with an economical and valid assessment method.

2. Methods

2.1 Samples and Procedure

This cross-sectional study includes two samples, selected by different sampling procedures (see below). The first was used for the development of CIRA scores and risk categories. The second served to test the validity of CIRA risk categories. Ethical approval was not required because for this study since data were fully anonymized, in accordance with Article 2, alinea 2, of the Federal Act on Research involving Human Beings (HRA), Switzerland (see: https://www.admin.ch/opc/en/classified-compilation/20061313/index.html - Chapter 1, section 1).

Development sample. The development sample included all persons detained in the Pöschwies prison (Zurich, Switzerland) on March 23, 2020. Pöschwies has 397 places for post-trial detention (occupation rate = 92%) and includes all kinds of prison regimes (e.g., common, open, maximum security). A total of

365 males was included (M_{Age} = 41, *SD* = 13, range: 20-83). Data were collected by prison staff from institutional records.

Validation sample. The validation sample included 192 male persons detained in the Champ-Dollon prison (Geneva, Switzerland) on March 15, 2020 (M_{Age} = 37, *SD* = 11, range: 19-74). Champ-Dollon has 398 places for pre-trial and post-trial detention. At the time of data collection, 650 people were detained in Champ-Dollon (occupation rate: 163%). The sample included all people clinically classified as vulnerable for COVID-19 (*n* = 45), identified after a first medical screening of the whole prison population, and a random selection of 147 of those classified as non-vulnerable (matching 1:3 for severe course of COVID-19, see section 2.3). Data were collected by the medical staff from medical files.

2.2 Development of the CIRA

The CIRA focuses on risk factors identified by the WHO[5] and the FOPH[6] as having a prognosis of severe COVID-19, based on laboratory cases in China. It includes seven factors: Age ≥ 60 and six medical conditions: cardiovascular disease, diabetes, hypertension, chronic respiratory disease, immunodeficiency, and cancer. Although the FOPH suggests age ≥ 65 as a risk factor, [6] considering the higher vulnerability of persons residing in prison,[16] the threshold was conservatively reduced to 60 years to take into account the correctional context. Older age in prison is frequently considered even lower, from 50 years of age.[17]

The CIRA combines these seven risk factors to derive an absolute risk increase in mortality rate. If a risk factor is absent, its score is 0. If a risk factor is present, a score ranging from 3.7 (for cancer) to 8.9 (for cardiovascular disease) is assigned. Scores correspond to the increased risk of COVID-19 death relative to the death rate among persons for whom the risk factor is absent. Death rates were extracted from the study of the Novel Coronavirus Pneumonia Emergency Response Epidemiology Team (NCPERET),[12] which includes information on 72,314 cases of COVID-19 in China and was the most complete data available at the time of collection. Since the study did not provide death rates among patients with immunodeficiency, the increased death risk for any comorbidity (i.e., combined; 4.1) was assigned for this risk factor. The sum of the risk factors' score is the CIRA score, which ranges from 0.0 to 36.9, with higher values representing higher mortality risk.

2.3 Variables

Risk factors: Seven risk factors were collected: age, cardiovascular disease, chronic respiratory diseases, immunodeficiency, diabetes, hypertension, and cancer.

Vulnerability according to national recommendations: We derived a binary criterion of being vulnerable as defined by the FOPH,[6] which considers detained persons vulnerable if they are aged ≥ 65 years and/or if they have any of the underlying medical conditions listed above.

Vulnerability according to clinical evaluation: A senior medical doctor (LG) derived a four-level classification of vulnerability according to the definition provided by the Division of Prison Health of the Geneva University Hospitals (see Appendix 1). The criteria were developed according to (1) national recommendations from the FOPH, (2) literature reviews on risk factors for COVID-19 severe course of disease, and (3) consensus of medical doctors from the Division of Prison Health about factors to consider.

2.4 Analyses

Sample size calculation: To detect a sensitivity or specificity of 95% with significance level of 5% and precision of 3%, 103 participants were required.[18]

Development of the CIRA: In the development sample, we first computed the prevalence rate of risk factors with 95% confidence intervals (CI). We also calculated correlations between risk factors (Phi-coefficient) and their significance. Then, we applied the CIRA algorithm to derive CIRA scores. We summarize the distribution of scores based on kernel density estimation and percentiles, which served to derive CIRA risk categories. By last, the proportions of persons in each risk category with 95% CI was presented.

Validation of the CIRA: In the validation sample, we tested whether the CIRA was valid (criterion validity) by comparing its risk categories to (1) the national recommendations of the FOPH and (2) the clinical evaluation of medical staff, considered as two gold standards. For the clinical evaluation, we first used "vulnerable" versus "non-vulnerable" detained persons (to test the discriminative ability of CIRA "elevated risk" category) and then the highest risk category ("extremely vulnerable") versus other risk categories (to test the discriminative ability of CIRA "high risk" category). We used Area Under the Curve (AUC) and defined the best threshold categories based on the Youden *J* statistic that maximized sensitivity and specificity. Analyses were conducted in Stata 15.0.

3. Results

3.1 Development of the CIRA

In the development sample, regarding the prevalence rate of risk factors for COVID-19 mortality, 10.7% (95% CI [7.9, 14.3], $n = 39$) of the subjects were age 60 or older. The most prevalent medical condition was hypertension (11.8% [8.8, 15.5], $n = 43$), followed by cardiovascular disease (5.5% [3.6, 8.4], $n = 20$), diabetes and chronic respiratory disease (both 3.8% [2.3, 6.4], $n = 14$), and immunodeficiency (3.0% [1.7, 5.4], $n = 11$). Cancer was less common (0.5% [0.1, 2.2], $n = 2$). The correlations between risk factors are presented in Table 1. Age $\geq$ 60 was significantly correlated with hypertension ($r = .29$, $p < .001$) and cardiovascular disease ($r = .23$, $p < .001$). Cardiovascular disease was also significantly correlated with hypertension ($r = .36$, $p < .001$) and diabetes ($r = .20$, $p < .001$). In addition, hypertension was correlated with diabetes ($r = .15$, $p = .005$).

Table 1 *Correlation between Risk Factors*

Risk factor	1	2	3	4	5	6
1. Age 60+	-					
2. Cardiovascular	.23 (<.001)	-				
3. Diabetes	.02 (.658)	.20 (<.001)	-			
4. Hypertension	.29 (<.001)	.36 (<.001)	.15 (.005)	-		
5. Respiratory	-.02 (.663)	-.05 (.360)	.03 (.513)	-.03 (.584)	-	
6. Immunodeficiency	.04 (.415)	.03 (.594)	-.04 (.503)	.04 (.505)	-.04 (.503)	-
7. Cancer	-.03 (.625)	-.02 (.734)	-.01 (.778)	-.03 (.606)	-.01 (.778)	-.01 (.803)

Note: Pearson correlations (Phi-coefficient). *P-values* in parentheses. $N = 365$.

Figure 1 presents the distribution of CIRA scores. The distribution was skewed to the right. Although the mean was 2.2 (95% CI [1.7, 2.6]), scores ranged from 0.0 to 24.7. Percentiles 66, 75, and 90 corresponded to the scores 0.0, 4.1, and 5.7, respectively.

Based on the distribution of CIRA scores and national recommendations (every person with one risk factor had to be considered at risk) we proposed a three-level classification of risk: average risk (< 3.7), elevated risk (3.7-5.7), and high risk (> 5.7; see Table 2 for a complete description of CIRA risk factor scores and risk categories). Most detained persons had a score of 0.0 (72.6% [67.8, 77.0], *n* = 265) because they had no risk factor and were classified as "average risk". Another group (17.5% [14.0, 21.8], *n* = 64) had scores between 3.7 and 8.8 and were classified as "elevated risk". A smaller group (9.9% [7.2, 13.4], *n* = 36) had higher scores, spanning 8.9 to 24.7, and were classified as "high risk".

Table 2 *CIRA Risk Factors, Scores, and Risk Categories*

No.	Risk factor	Coding	Score (if risk factor is present)
1	Age	0 = <60, 1 = 60+	5.4
2	Cardiovascular disease	0 = absent, 1 = present	8.9
3	Diabetes	0 = absent, 1 = present	5.7
4	Hypertension	0 = absent, 1 = present	4.7
5	Chronic respiratory disease	0 = absent, 1 = present	4.4
6	Immunodeficiency	0 = absent, 1 = present	4.1
7	Cancer	0 = absent, 1 = present	3.7
CIRA score (sum of scores):			
Risk category:		Average (<3.7) / Elevated (3.7-5.7) / High (>5.7)	

Note: Scores represent the increased mortality compared to the group without the risk factor. CIRA = COVID-19 Inmate Risk Appraisal.

3.2 Validation of the CIRA

In the validation sample, based on the national recommendations, 21.4% (*n* = 41) of the persons were considered vulnerable for COVID-19 mortality. CIRA risk categories had a high capacity in discriminating vulnerable individuals (AUC = .99; 95% CI [.98, 1]). The category “elevated risk” maximized sensitivity (100%) and specificity (97.4%, *J* = .97). CIRA classification identified all individuals considered vulnerable by the national recommendations plus 4 (2.1%), due to the lower age threshold used by the tool.

CIRA had even higher capacity in discriminating vulnerable individuals according to clinical evaluations (AUC = 1 [1, 1]). The category "elevated risk" maximized sensitivity and specificity (both 100%, *J* = 1). CIRA identified the same individuals as being vulnerable for COVID-19 mortality as the medical staff (*n* = 45). When considering the individuals classified as extremely high risk by medical staff (*n* = 9), the category "high risk" had a high discriminatory capacity (AUC = .97 [.95, 1], *J* = .86, sensitivity = .89, specificity = .97).

4. Discussion

4.1 Main results

In the development sample, 72.6% of detained people were classified as "average risk", 17.5% as "elevated risk", and 9.9% as "high risk". Cardiovascular disease and comorbidities classify people as high risk, which makes sense since the first is the leading cause of death worldwide [19] and the second is generally associated with worse health outcomes.[20] [21] Criterion validity analyses indicated that CIRA risk categories have a high discriminative ability and thus, that the CIRA is a valid tool. In addition, our study gave an accurate overview of the prevalence rate of risk factors for COVID-19 mortality. More than one in four detained persons had a risk factor for COVID-19, with hypertension, cardiovascular disease, and age ≥ 60 being the most prevalent.

4.2 Implications

Using the CIRA to assess COVID-19 risk has advantages compared to national recommendations or clinical evaluations. Using a standardized screening tool may save time and resources to prison staff, and reduce ambiguity in decision-making (higher reliability).[22] This allows prison managers prioritizing cases and making intervention plans. An Excel algorithm to calculate scores and associated risk category is presented in Appendix 2.

Our findings also allow for prevention recommendations based on risk factors. As hypertension and cardiovascular diseases are prevalent in our sample, treating these conditions may be a viable preventive measure for COVID-19 death in prison. For example, hypertension is the most important modifiable risk

factor for premature cardiovascular disease.[23 24] The risk of severe illness from COVID-19 is also higher among older prisoners. It would be beneficial for prisoners aged 60 and above to receive particular attention related to COVID-19 risk or be diverted to outside facilities providing appropriated care.

4.3 Limitations and Future Directions

The present study has limitations. Knowledge on risk factors for COVID-19 mortality is still limited and, therefore, important variables may not be included in the guidelines of national and international organizations. For example, recent studies indicate that smoking and obesity are risk factors for hospitalization after infection.[25-27] In addition, the CIRA scores assigned to risk factors relied on data from China. Although similar findings have been reported in other regions,[13-15] their applicability to other countries is still uncertain. Therefore, the variables and scores used in CIRA should be considered preliminary and may need to be adjusted in the future.[28] A website was created for this purpose (see www.prison-research.com), [29] and the algorithm to compute CIRA scores and associated risk categories will be updated regularly according to new scientific evidence. Finally, the empirical evidence for the cut-score of the high-risk category is limited because of the small sample size (n = 9) in the highest clinical risk category. Besides, we believe that the CIRA can be used in custodial settings to help practitioners protecting detained persons from COVID-19.

Declarations

Only the anonymous data was collected and informed consent for this retrospective study was waived.

Competing Interests: All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; and no other relationships or activities that could appear to have influenced the submitted work.

Contributors: Conceptualization, methodology and validation: all authors; formal analysis: LCG and SB; investigation: AR and LG; data curation; LCG and LG; drafting – original draft preparation: LCG, SB, and MW; drafting – review and editing: LG, HW, JPS, AN, AR, AR, and JE; supervision: JE and HW; project administration: AR. All authors approved the final version of the manuscript.

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Appendices

Appendix 1

Criteria for COVID-19 Vulnerability and Risk Classification used by the Penitentiary Medicine Service of the Geneva University Hospitals (on March 15, 2020)

Risk classification	Criteria	*n*
Extremely high	- Chronic pulmonary disease / Pulmonary fibrosis - Age >60 and at least on vulnerability factor* - Human Immunodeficiency Virus CD4<200	9
Very high	- Asthma - Diabetes - Heart disease - Stage 4 renal failure - Human Immunodeficiency Virus CD4 200-500	22
High	- Age >60 without comorbidity - Human Immunodeficiency Virus CD4>500	6
Moderated	- Hypertension	8

Note: Clinical risk classification applied in the validation sample (n = 192).
* Cancer, immunodeficiency, chronic respiratory disease, diabetes, cardiovascular disease, and hypertension.

Appendix 2

Display of the Excel Algorithm to Compute CIRA Scores and Risk Categories

COVID-19 Inmate Risk Appraisal (CIRA)

Please select the appropriate category in "Coding".

Risk factor	**Coding**	**Score**
Age	<60	0
Cardiovascular disease	no	0
Diabetes	no	0
Hypertension	no	0
Chronic respiratory disease	no	0
Immunodeficiency	no	0
Cancer	no	0

CIRA score	0
Risk	AVERAGE

Last actualization: 20/04/2020
Available from: www.prison-research.com

Figures

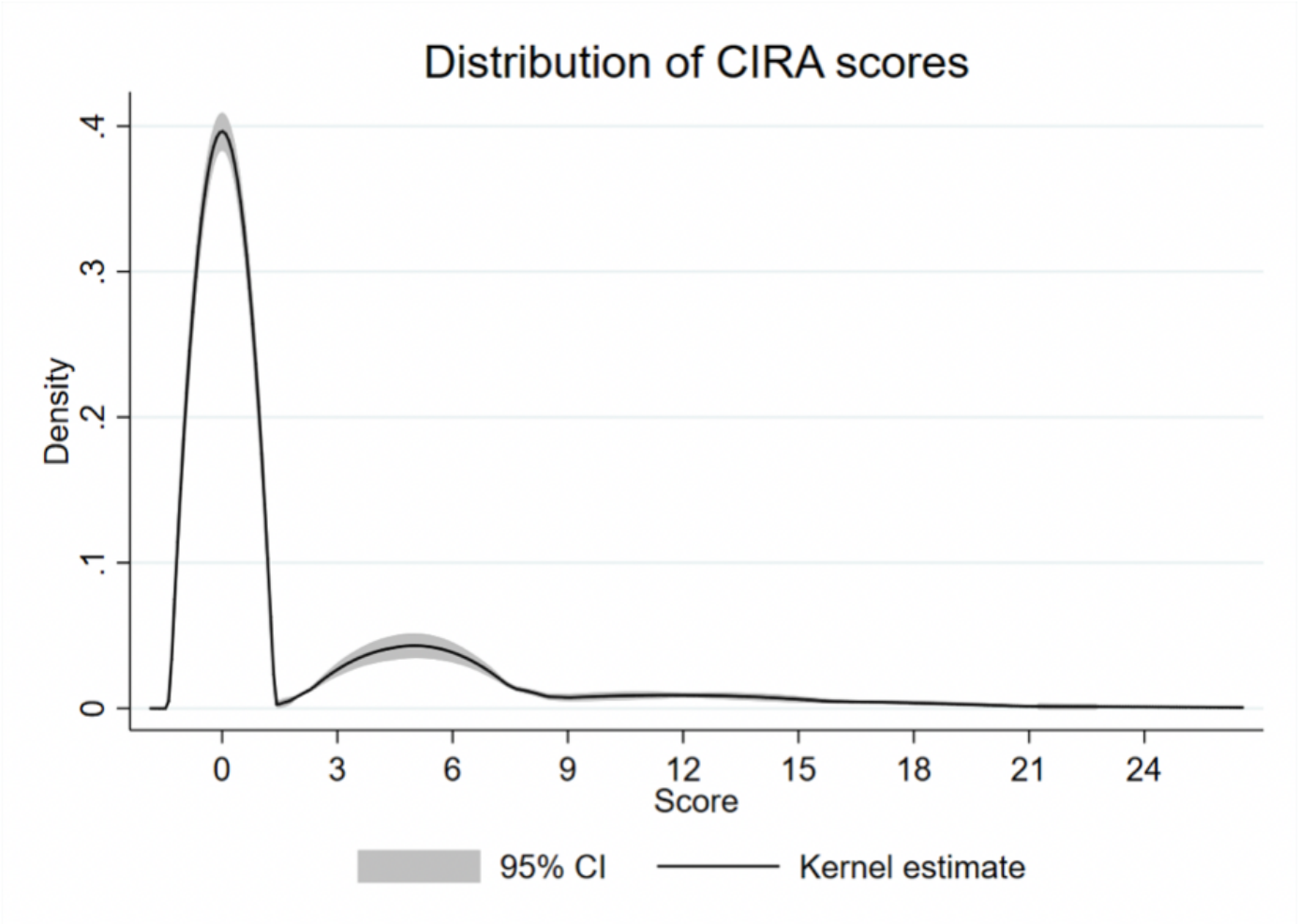

Figure 1

Distribution of CIRA scores in the development sample (n = 365). Kernel density with adaptive estimator.