Crime Prevention and Community Safety (2021) 23:252–263
https://doi.org/10.1057/s41300-021-00119-9

ORIGINAL ARTICLE

Mapping CPTED parameters with the *LookCrim* application

Feliz Gouveia[1] · Ana Sani[1,2,4] · Maria Guerreiro[1,5] · Vanessa Azevedo[1,2] · Hugo Santos[1] · Laura M. Nunes[1,2,3]

Accepted: 14 May 2021 / Published online: 4 June 2021

Abstract

Crime prevention through environmental design (CPTED) is a multi-disciplinary approach to deterring criminal behavior through environmental design. CPTED strategies rely upon the influence on offender decisions that precede criminal acts by affecting the built, social, and administrative environment. We introduce an innovative technological tool, the *LookCrim* application, based on CPTED's principles, to assess characteristics of specific physical spaces. This article describes the developed web platform and mobile app tools and their functional overview and explores some opportunities and challenges, such as the integration in smart cities, and ethical and legal issues. The *LookCrim* application gathers geo-tagged information enriched with CPTED characteristics—natural surveillance, natural access control, territorial reinforcement and maintenance, organized by categories defined by the European Committee for Standardization. The LookCrim application may be useful for organized data acquisition on urban spaces to develop empirical studies that will support environmental urban design decisions.

Keywords Crime prevention · CPTED · Criminology · Security promotion · Urban design

✉ Laura M. Nunes
lnunes@ufp.edu.pt

[1] University Fernando Pessoa (UFP), Praça 9 de abril, n.º349, 4249-004 Porto, Portugal

[2] Observatory Permanent of Violence and Crime (OPVC), UFP, Porto, Portugal

[3] Centro de Investigação Em Justiça E Governação (JusGov), University of Minho, Braga, Portugal

[4] Centro de Investigação Em Estudos da Criança (CIEC), University of Minho, Braga, Portugal

[5] Fernando Pessoa Energy, Environment and Health Research Unit (FP-ENAS), UFP, Porto, Portugal

Introduction

The idea of modifying the environment to reduce crime gained momentum in the 1960s, when Jacobs (1961) first suggested that under constant activity and surveillance, environments could be safer. This idea was further supported by Jeffery (1971), which first introduced the term *Crime Prevention Through Environmental Design (CPTED)*. CPTED is a multidisciplinary approach which supports that by modifying urban spaces, built environments may reduce or even prevent crime incidences (International CPTED Association [ICA] 2020). In this sense, urban design based on this concept may empower inhabitants to gain control over the territory if a sense of community is built and, therefore, reduce the opportunity of offenders to commit crimes (Owusu et al. 2015; Iqbal and Ceccato 2016).

Before intervention and prevention measures are designed and implemented, a careful and comprehensive assessment of urban space and environment characteristics should be performed. This article proposes a tool for a systematic collection of spatially distributed data on characteristics of spaces. This document is organized as follow: we introduce the CPTED rationale, principles and guidelines, and present the aims of the current study. Then, we describe the *LookCrim* application focusing on both the development process and functional analysis. Finally we identify challenges and opportunities before the concluding remarks.

Crime prevention through environmental design (CPTED)

The first generation of the CPTED approach focuses solely on blocking crime opportunities by changing space to enforce positive behaviors through minimization of environmental support for criminal actions. The second generation expanded the concept to the social relations within the neighborhood, which is being further developed in the third generation of CPTED that discusses the importance of quality of life with a long-term impact of existing practices on future generations (Mihinjac and Saville 2019). To provide a uniform approach to CPTED, the European Committee for Standardization (CEN) published a standard—the CEN 14383 series (European Committee for Standardization 2007; van Soomeren et al. 2014), that supports the inclusion of safety and security issues in urban planning and design. When correctly applied and enforced, CPTED principles discourage crime and improve quality of life, reducing fear, as observed in cities where programs were implemented and adopted. For instance, in Seoul, South Korea, sufficient closed-circuit television, street lighting, and maintenance played a significant role in mitigating fear of crime (Lee et al. 2016); in Accra and Kumasi, Ghana, CPTED principles were applied by creating ‘security islands’ (i.e., building higher walls with burglar proof windows and doors) with a low community solidarity in middle- and upper-class neighborhoods (Owusu et al. 2015).

The principles that support CPTED are natural surveillance, natural access control, territorial reinforcement, and maintenance and management (Jeffery 1971; Newman 1972; European Committee for Standardization 2007). Briefly:

1. natural surveillance relies on buildings' design to maximize passive surveillance. A mix of uses of spaces attracts people for long hours, day and night, and encourages pedestrian movement to keep intruders visible and less likely to commit crimes;
2. natural access creates a perception of risk for offenders, as they are guided through pre-defined pathways;
3. territorial reinforcement distinguishes private from public spaces, discouraging offenders from trespassing as the sense of community control over territory grows;
4. maintenance and management imply that there is concern and control over the territory with little tolerance to disorder.

Inherent to the CPTED's principles, we should also address the Three D Approach (National Crime Prevention Council 2003), which consists on a pragmatic approach focused on three central aspects to consider in a space, namely:

1. designation: to capture the space or area attending to their intent uses and purposes of utilization;
2. definition: focused on information about the space, attending to the expected and observed behaviors, uses and borders, exploring if there is convergence between its purposes and uses effectively made;
3. design: focused on the shape and how it contributes to a larger or smaller behavioral regulation.

CPTED's principles, standard's guidelines and strategies were the theoretical support for the development of the application LookCrim, which is described below.

Current study

The Observatory Permanent of Violence and Crime—OPVC (OPVC 2020), hosted at University Fernando Pessoa, Porto, Portugal, develops research on the environmental factors that influence violence and crime in urban environments since 2012, involving a multidisciplinary team. CPTED is a topic still underexplored in Portugal (Saraiva et al. 2020) and represents one line of research at OPVC, which is particularly interested on crime assessment in urban areas.

In this context, OPVC developed a software tool (available in a web platform and as a smartphone app) to easily collect and represent georeferenced data on CPTED's characteristics of a specific physical space: the *LookCrim* application. Despite other available technological tools in the field of security and criminology [e.g., Solymosi et al. (2015) and Chataway et al. (2017) to evaluate fear of crime or to report

criminal incidents to the police (Oduor et al. 2014)], to the best of our knowledge, this is the first tool to assess and characterize spaces based on CPTED criteria, for a systematic collection and organization of information.

The main objective of this article is to present this tool, describing both its development process and functional analysis. Besides, we reflected on the main challenges and opportunities of the *LookCrim* application, discussing its applications, implications, and limitations.

The *LookCrim* tool

The *LookCrim* application provides systematic data collection and organization to support a spatial–temporal study of crime based on CPTED categories (European Committee for Standardization 2007; van Soomeren et al. 2014) and was developed for both a web platform and a mobile unit (smartphone). The smartphone app allows a registered user to characterize a given location, on site, whereas the web platform does it in a remote manner. As of now, there are no plans to allow anonymous, non-authorized, users to use the app.

There are two authorization levels for users of the system: *administrator* and *user*. The *administrator* has privileges to create and manage users (e.g., level, status), and to edit all registered features. The *user* profile has access to the list of registered features and their characterization and has the right to edit only the features that he/she has created.

The tool is available in Portuguese, English and French, and after data collection, information may be extracted into CSV (Comma-separated values) or Excel formats for further statistical analyses. The mobile app works also without an internet connection, storing data locally and then submitting information to the main server database when an internet connection is available.

The CPTED's categories included in the *LookCrim* application are detailed in Table 1 Additionally, users may add categories/information into a space devoted to notes. As previously mentioned, these categories were based on the CPTED's principles and Three D Approach, focused merely on spatial, landscape, and architectonic characteristics, according to first generation perspective. Indeed, while second generation[1] of CPTED's programs focused also on social, cultural and community characteristics (Cozens and Love 2015; Cozens et al. 2005) and the third generation includes digital media and the so-called green technology (Mihinjac and Saville 2019), the *LookCrim* application focused all attention on all characteristics that traditionally and according to the first generation describe spaces and their physical aspects.

[1] To assess second generation characteristics, our team developed two specific measures: The Diagnosis of Local Security and the Diagnosis of School Environment, that complements data gathered through the application and vice-versa.

Table 1 CPTED's categories (European Committee for Standardization 2007)

Corners with low visibility	
Spaces with low visibility (e.g., abundant, and pruned vegetation, alleys, etc.	
Spaces without surveillance (including humans and technological devices)	
Spaces not attended by people	
High risk spaces	Tunnels or footbridges
	Alleys with no way out
	Parking lots or restricted areas
	Abandoned land with uncontrolled vegetation
	Abandoned houses with the possibility of hiding/sheltering people
	Areas or streets with no formal or informal control
Accesses	Narrow streets with corners or other barriers that diminish visibility
	Stairs, glades or ramps without visibility
Lighting	Scarce or poorly distributed
	Poor lighting of pedestrian path
Functionalities	Mixed zone (i.e., commercial and industrial buildings, houses)
	Public and private spaces not separated
	Absence of leisure/green spaces
Conditions	Housing degradation
	Degradation of shared zones
	Pavement degradation
	No delimitation of pedestrian paths
	Barely visible or missing signage
	Incivilities promoting degradation (e.g., litter on the streets, destroyed equipment, unsolicited graffiti)
Attendance	Antisocial neighborhood
	Presence of drugs' use and sale
	Notorious population fluctuation

Development process

Having defined the functional, non-functional, software and the quality requirements (available upon request from the authors), we followed a classic client–server pattern architecture, where multiple clients request and receive services from the host computer. The client is the device in which the application is running, be it the web or the mobile application, and its respective user, making request to the server. The server, in turn, will make requests to the database to get the desired data or to store new data. The data corresponds to the features registered or to be registered.

The *LookCrim* mobile application uses two types of web services: communication with the API server and communication with the Open Street Maps (OSM)

Table 2 Debugging tests performed

Created different types of features to ensure that the value of the variables was passed from function to function correctly
Inserted several features to the local database to ensure that all information was saved correctly
Submitted the API services to tests to verify if the authentication fields of a user were sent correctly to the server and if the token returned by the server was correct and the user was authenticated
Submitted features to the server through the mobile application to check for consistency and preservation of fields and field data by sending information in JSON format and the total token for correct association to the user
Exposed the application to a lack of internet access during data submission to verify if the application detected the true status of submission to the server
Exposed the OpenSourceMap *Nominatim* API to different number of requests in a short time to check for its response
Tested for several requests sending different coordinates, emulating occurrences at different locations to verify if the address that the API returns is the location where the user is at that moment

API, by means of the *Nominatim* search engine. Use of OSM allows for the features to have specific spatial information, allowing also the use of the smartphone's GPS. The language presented by default is Portuguese (PT), but can be easily changed to English (EN) or French (FR) on the web application.

The tools used for the development of the web application were: Laravel[2] (a structured development framework for PHP); PHP[3] (a general purpose open-source scripting language, suitable for web development); and MariaDB[4] (a database used for storing data such as features and user data).

The tools used for the development of the mobile application were: Flutter[5] (the open-source software development kit created by Google for developing applications for Android, iOS, Desktop or Web); Dart[6] (a programming language developed by Google); and SQLite[7] (a database used for storing locally features, events and user data).

We performed extensive testing (Table 2) to minimize bugs and include visualization of the application at several different screen resolutions to ensure the good visual aspect of graphic components.

Functional description

From a functional perspective, the *LookCrim* application presented in this study requires information on the where—exact location of target area, the

[2] https://laravel.com/.
[3] https://www.php.net/.
[4] https://mariadb.org/.
[5] https://flutter.dev/.
[6] https://dart.dev/.
[7] https://www.sqlite.org/.

Fig. 1 Landing page of applications

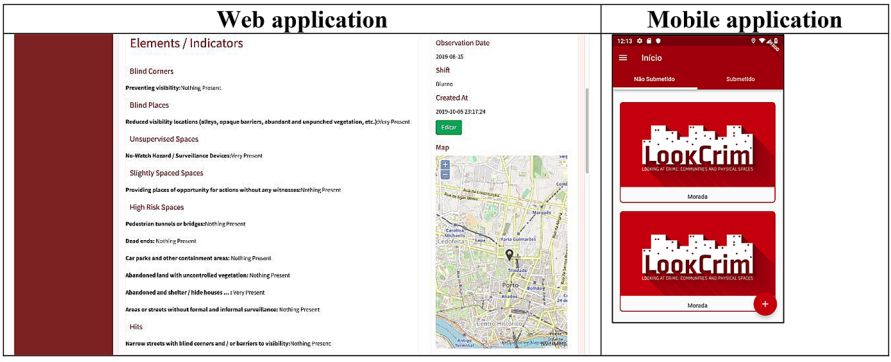

Fig. 2 Details view and editing options

what—general identification of the identified feature, and the who—identification of stakeholders. *LookCrim*, available as a mobile app or a web platform, enables the user to characterize the physical space and to attach pictures and observations to a readily geo-tagged record through an interactive and user-friendly interface.

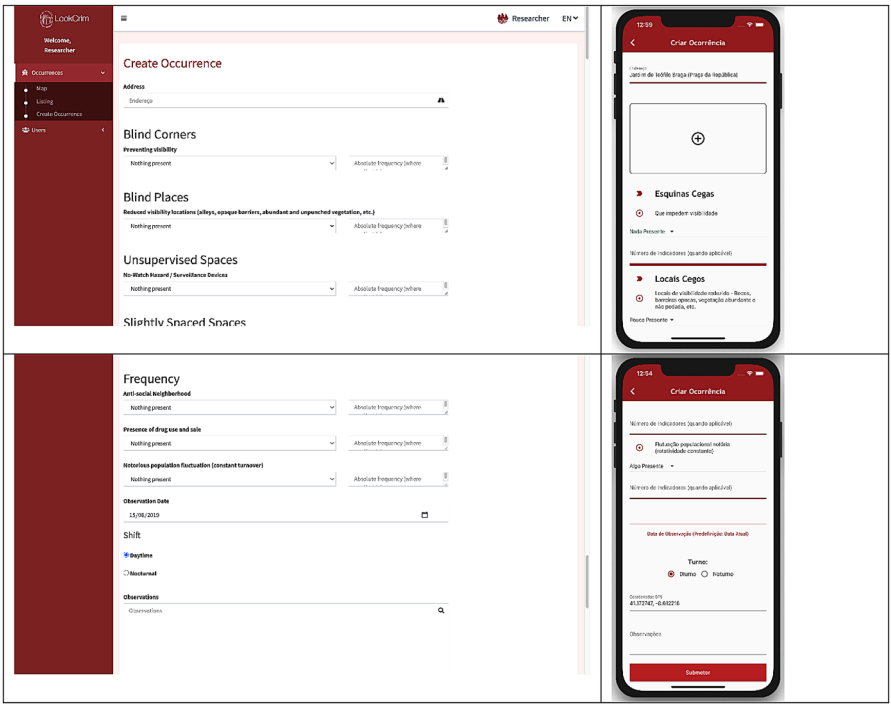

Fig. 3 Create a new feature in the web platform and mobile app

Upon login, the user is shown a map of the region with markers for all CPTED features registered in that area, the option to change the language, view the map, see the list of features, and create a feature for a specific location (Fig. 1).

Each feature is presented with a georeferenced icon in the map view which, upon selection (Fig. 1), directs users to a page with the feature details (Fig. 2). Those details may be edited or deleted by the administrator and by the user who created the information in the first place.

To add a feature in the web platform, the user may choose from pre-defined CPTED's categories (Table 1). The user is asked to rate the presence of a feature in a 4-point Likert scale, ranging from *not present at all* to *very present; and* if applicable, the absolute frequencies (Fig. 3). Additionally, users can introduce date, time of day, notes and add photos.

The application uses data about longitude and latitude for geo-referencing, simply by clicking on the map on the location of the feature to be registered. On the mobile app, the feature date is automatically stored (Fig. 3).

Opportunities and challenges

Conceptually rooted on CPTED, the *LookCrim* application allows for easily registering the spatial conditions, based on the CPTED features, that may encourage criminal activity in a given space. This tool provides a systematic registration and description of physical spaces, to support the analysis of its proneness to crime.

Results acquired through this application may be very useful not only for researchers, but also for stakeholders committed to crime reduction and security improvement (e.g., police, administration services). The application has been used in Porto (Portugal) and, due to its systematic approach to spaces' characterization, may be applied at other national and international sites and provide a basis for cross comparison. The application stores data on locations for further statistical analyses to be performed by different stakeholders.

Results from this application may be cross-analyzed with actual crime occurrences, allowing professionals and decision makers to understand crime and space characteristic interactions, and support environmental urban design decisions and promote empirical studies.

The mobile application besides sharing the same functionalities as the web application allows authorized users to register features in real time, based on the user's mobile GPS, and add photographs taken also on place. After completing the registration form, data is saved locally, if there is no internet access or, otherwise, it is immediately sent and stored in the remote database, and can be viewed in both the mobile and web applications.

In the era of the SMART cities, data acquired with this application has the potential to be integrated with other platforms' data (e.g. from ThingsBoard) using the physical location. Smart cities rely on an intensive use of digital sensor technology, high speed wireless data networks, and information systems that manage and take full advantage of the data (Harrison and Donnelly 2011). It is thus possible to add the CPTED markers to semantic rules and to add urban design to the daily management decisions of the city. For example, data about traffic, people movements on public transportations, crime and offences, CPTED's indicators can be better put into context if they are all semantically integrated in a single platform. The focus on micro-level points (e.g., specific streets or physical spots) that are georeferenced is also an advantage, making possible small-scaled interventions.

Despite these opportunities, there are nevertheless sensitive issues that need to be addressed. Main challenges involving *LookCrim* application are related to legal and ethical issues. CPTED is widely accepted as a strategy in which city planners may rely on to make safer spaces. Nonetheless, some authors discuss their negative aspects, by analogy to the dark side in planning and architecture. Some legal issues arise from this discussion and Cozens and Love (2017) argue that this planning can be an oppressive mechanism of social control. Some questions arise from this discussion are as follow:

- Should the CPTED database be opened to all citizens? Should citizens access all CPTED information concerning their neighborhood? Could this bring some form of discrimination based on lack of or of excessive crime prevention?
- Who is liable for wrong or biased CPTED markers? Would, in a security-based society, CPTED be used to influence security decisions, eventually not necessary?
- How can citizens or other actors participate in the CPTED classification of the city and analyze and modify CPTED decisions? Until now, the application was only developed to be used by researchers or trained observers, such as law enforcement officers, criminologists, urban planners, and decision makers and volunteered geographic location is not considered.

Those and other legal issues (e.g., data protection through user authentication) of CPTED are central to their correct application, evaluation, and assessment in a specific context. All stakeholders should be able to participate in the process and benefit from its use. For this to be a reality, the identified legal issues should be taken care of and a clear framework defined (Freitas et al. 2019).

Lastly, despite the advantages of this tool, it is not free of limitations—the mobile application is only currently available for Android smartphones, despite being our aim to further adapt it to iOS. The LookCrim app is only available upon request to the authors, being unavailable for download at the app store. Lastly, another potential limitation is the requirement of previously knowledge (or instead formal training) concerning CPTED's principles and assessment before use of the LookCrim tool. Indeed, in a pilot study we asked to four raters—with different levels of previous knowledge about CPTED's principles—to assess seventeen physical spaces using the LookCrim application. Inter-rater agreement reliability tests suggested that percentages of agreement ranged from 47.06 to 100% for individual categories and an overall percentage of agreement of 77.65% ($\kappa = 0.48$, SE = 0.05, 95% CI 0.39; 0.57). Individual differences on the previous knowledge about CPTED's may be a potential reason to low values of percentage of agreement; notwithstanding only a large-scale study may provide a more precise figure about variability in ratings and provide explanatory causes. However, it should be noted that this kind of evidence is beyond the scope of the current paper, which aims to present the application and its development process.

Final remarks

In this article, we presented *LookCrim*, both as a web platform and as a mobile app, an innovative tool in the fields of security and criminology. Its main goal is to systematically characterize physical spaces based on CPTED's principles, to promote public security and prevent criminal occurrences. As a result from the assessment through the application, we can identify critical points or areas that can empirically guide environmental interventions. Indeed, besides an overall overview of the spaces according to CPTED's principles, we can also achieve a

detailed identification of the current characteristics that promote or inhibit crime. The application may be available in any language, provided the translation of respective categories.

Based on our work on the CPTED approach and the study of crime, we proposed further the integration of the CPTED geo-referenced markers with the smart city framework, so that information about urban design and planning decisions could integrate with the feed of sensor data. The integration of heterogeneous data in smart cities environments is an essential step for the stakeholders to take full advantage of the flow of data and produce effective management decisions. So, in the future, we plan to make the platform available to interested stakeholders so that real life, real-time data can be collected and integrated within the CPTED database.

Considering both opportunities and challenges, we hope that potential users of the *LookCrim* application and the web platform, such as law enforcement officers, criminologists, urban planners, and decision makers, benefit from its use, contributing to urban design improvement and to avoid places' stereotyping by the public.

Funding This work was supported by the Portuguese Science and Technology Foundation (FCT) under Grant of project 'LookCrim—Looking at Crime: Communities and Physical Spaces' (PTDC/DIR-DCP/28120/2017).

References

Chataway, M., R. Hart, R. Coomber, and C. Bond. 2017. The Geography of Crime Fear: A Pilot Study Exploring Event-Based Perceptions of Risk Using Mobile Technology. *Applied Geography*. 86: 300–307. https://doi.org/10.1016/j.apgeog.2017.06.010.

Cozens, P., and T. Love. 2015. A Review and Current Status of Crime Prevention Through Environmental Design (CPTED). *Journal of Planning Literature* 30(4): 393–412. https://doi.org/10.1177/0885412215595440.

Cozens, P., and T. Love. 2017. The Dark Side of Crime Prevention Through Environmental Design (CPTED). In *Oxford Research Encyclopedia of Criminology*. Retrieved 26 Nov 2020. https://doi.org/10.1093/acrefore/9780190264079.001.0001/acrefore-9780190264079-e-2.

Cozens, P., G. Saville, and D. Hillier. 2005. Crime Prevention Through Environmental Design (CPTED): A Review and Modern Bibliography. *Journal of Property Management* 23(5): 328–335. https://doi.org/10.1108/02637470510631483.

European Committee for Standardization. 2007. *CEN/TC 325—Crime Prevention Through Building, Facility and Area Design*. Available at: https://standards.cen.eu/dyn/www/f?p=204:32:0::::FSP_ORG_ID:6306&cs=133518429ECB0D4DDB06C8583A7A5CD0D.

Freitas, P.M., L. Nunes, F. Gouveia, M. Guerreiro, and A. Sani. 2019. Smart Cities and Security—A Preventive Approach. In *Intelligent Environments*, ed. A. Munoz, et al., 206–221. Amsterdam: IOS Press. https://doi.org/10.3233/AISE190045.

Harrison, C., and I.A. Donnelly. 2011 A Theory of Smart Cities. In *55th Annual Meeting of the International Society for the Systems Sciences*. Hull, UK.

International CPTED Association (ICA). 2020. Retrieved 26 Nov 2020, from https://www.cpted.net/.

Iqbal, A., and V. Ceccato. 2016. Is CPTED Useful to Guide the Inventory of Safety in Parks? A Study Case in Stockholm, Sweden. *International Criminal Justice Review* 26(2): 150–168. https://doi.org/10.1177/1057567716639353.

Jacobs, J. 1961. *The Death and Life of Great American Cities*. New York: Random House USA Inc.

Jeffery, C.R. 1971. *Crime Prevention Through Environmental Design*. Beverley Hills, CA: SAGE Publications.

Lee, J.S., S. Park, and S. Jung. 2016. Effect of Crime Prevention Through Environmental Design (CPTED) Measures on Active Living and Fear of Crime. *Sustainability* 8: 1–16. https://doi.org/10.3390/su8090872.

Mihinjac, M., and G. Saville. 2019. Third-Generation Crime Prevention Through Environmental Design (CPTED). *Social Sciences* 8 (6): 1–20. https://doi.org/10.3390/socsci8060182.

National Crime Prevention Council. 2003. *Crime Prevention Through Environmental Design Guidebook*. Singapore: National Crime Prevention Council.

Newman, O. 1972. *Defensible Space: Crime Prevention Through Urban Design*. New York: Macmillan Company.

Observatory Permanent of Violence and Crime (OPVC). 2020. Retrieved 26 Nov 2020 from https://opvcufp.com/.

Oduor, C., F. Acosta, and E. Makhanu. 2014. The Adoption of Mobile Technology as a Tool for Situational Crime Prevention in Kenya. In *2014 IST-Africa Conference Proceedings*, 1–7. https://doi.org/10.1109/ISTAFRICA.2014.6880669.

Owusu, G., C. Wrigley-Asante, M. Oteng-Ababio, and A.Y. Owusu. 2015. Crime Prevention Through Environmental Design (CPTED) and Built-Environmental Manifestations in Accra and Kumasi, Ghana. *Crime Prevention and Community Safety* 17(4): 249–269. https://doi.org/10.1057/cpcs.2015.8.

Saraiva, M., A.V. Neves, H. Santos, M. Diniz, L. Jota, and P. Ribeiro. 2020. Crime Prevention Through Environmental Design (CPTED) in Portugal: Literature Review and Knowledge Networks. *Revista Portuguesa De Estudos Regionais* 52: 71–93.

Solymosi, R., K. Bowers, and T. Fujiyama. 2015. Mapping Fear of Crime as a Context-Dependent Everyday Experience that Varies in Space and Time. *Legal and Criminological Psychology* 20(2): 193–211. https://doi.org/10.1111/lcrp.12076.

van Soomeren, P., C.A. Davey, and A.B. Wootton, eds. 2014. *Review of CEN 14383. The Death and Life of Great European Standards and Manuals—Development and Implementation of the CEN 14383 Standards*. Retrieved 26 Nov 2020 from http://www.costtu1203.eu/wp-content/uploads/2014/10/03.-Review-of-CEN-14383-The-death-and-life-of-geat-European-standards-and-manuals.pdf.

Terms and Conditions

Springer Nature journal content, brought to you courtesy of Springer Nature Customer Service Center GmbH ("Springer Nature").

Springer Nature supports a reasonable amount of sharing of research papers by authors, subscribers and authorised users ("Users"), for small-scale personal, non-commercial use provided that all copyright, trade and service marks and other proprietary notices are maintained. By accessing, sharing, receiving or otherwise using the Springer Nature journal content you agree to these terms of use ("Terms"). For these purposes, Springer Nature considers academic use (by researchers and students) to be non-commercial.

These Terms are supplementary and will apply in addition to any applicable website terms and conditions, a relevant site licence or a personal subscription. These Terms will prevail over any conflict or ambiguity with regards to the relevant terms, a site licence or a personal subscription (to the extent of the conflict or ambiguity only). For Creative Commons-licensed articles, the terms of the Creative Commons license used will apply.

We collect and use personal data to provide access to the Springer Nature journal content. We may also use these personal data internally within ResearchGate and Springer Nature and as agreed share it, in an anonymised way, for purposes of tracking, analysis and reporting. We will not otherwise disclose your personal data outside the ResearchGate or the Springer Nature group of companies unless we have your permission as detailed in the Privacy Policy.

While Users may use the Springer Nature journal content for small scale, personal non-commercial use, it is important to note that Users may not:

1. use such content for the purpose of providing other users with access on a regular or large scale basis or as a means to circumvent access control;
2. use such content where to do so would be considered a criminal or statutory offence in any jurisdiction, or gives rise to civil liability, or is otherwise unlawful;
3. falsely or misleadingly imply or suggest endorsement, approval , sponsorship, or association unless explicitly agreed to by Springer Nature in writing;
4. use bots or other automated methods to access the content or redirect messages
5. override any security feature or exclusionary protocol; or
6. share the content in order to create substitute for Springer Nature products or services or a systematic database of Springer Nature journal content.

In line with the restriction against commercial use, Springer Nature does not permit the creation of a product or service that creates revenue, royalties, rent or income from our content or its inclusion as part of a paid for service or for other commercial gain. Springer Nature journal content cannot be used for inter-library loans and librarians may not upload Springer Nature journal content on a large scale into their, or any other, institutional repository.

These terms of use are reviewed regularly and may be amended at any time. Springer Nature is not obligated to publish any information or content on this website and may remove it or features or functionality at our sole discretion, at any time with or without notice. Springer Nature may revoke this licence to you at any time and remove access to any copies of the Springer Nature journal content which have been saved.

To the fullest extent permitted by law, Springer Nature makes no warranties, representations or guarantees to Users, either express or implied with respect to the Springer nature journal content and all parties disclaim and waive any implied warranties or warranties imposed by law, including merchantability or fitness for any particular purpose.

Please note that these rights do not automatically extend to content, data or other material published by Springer Nature that may be licensed from third parties.

If you would like to use or distribute our Springer Nature journal content to a wider audience or on a regular basis or in any other manner not expressly permitted by these Terms, please contact Springer Nature at

onlineservice@springernature.com