

Planned and Implemented Actions by Exercises

Francesco Russo and Corrado Rindone(✉)

DIIES, Università Mediterranea Di Reggio Calabria, 89100 Reggio Calabria, Italy
corrado.rindone@unirc.it

Abstract. On a global scale, natural and man-made disasters cause significant losses. For this reason, disaster risk reduction is a priority. This paper focuses on the exposure risk component during the occurrence and evacuation planning. There is a gap between the planned actions and their implementation during real emergency conditions. From the proposed reviewed literature different lacks emerge, including the evaluation of the risk reduction produced by each exercise or training actions. To build a bridge above this gap, it is necessary to design and experiment with training and exercises for putting into practice the planned evacuation procedures. A method is proposed to evaluate the exposure reduction by means of these actions. The literature distinguishes two main classes of actions: discussion-based, aimed at reviewing evacuation plans and procedures; and operation-based, aimed at simulating real experimentations with decision-making and people involved in a potential emergency situation. The expected outcome is to increase awareness of managers and users about the evacuation procedures for pursuing the final goal of exposure and therefore risk reduction. With increasing complexity and capabilities, exercises and training contribute to increasing the effectiveness of the planned actions. The paper is useful for risk managers and public decision-takers involved in the evacuation planning process to increase preparedness before an emergency event.

Keywords: disaster risk · risk reduction · evacuation planning · exercises

1 Introduction

On a global scale, natural and man-made disasters cause significant losses. In 2022, the Centre for Research on the Epidemiology of Disasters (CRED) estimates around US$223.8 billion deriving from recorded 387 natural hazards and disasters worldwide, with effects on 185 million individuals [1]. According to Sustainable Development Goals (SDG) and relative targets of the Agenda 2030 (SDG 1 – "End poverty in all its forms everywhere"; SDG 11 – "Make cities and human settlements inclusive, safe, resilient and sustainable"; SDG 13 – "take urgent action to combat climate change and its impacts") [2], there is a clear need to plan and implement a set of actions and policies for disaster risk reduction. This implies the necessity to define an emergency planning process and products to design a system that minimises risk and its three components [3]: occurrence, related to the probability or frequency that an emergency event happens; vulnerability related to the probability that the system resists to the effects produced by the event; exposure related to the number of people affected by the effects.

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The emergency planning products must support decision-takers to manage the transition of the system from a generic plan for the ordinary conditions (P_0) to a planned configuration that minimizes risks (P_{min}) in the extraordinary conditions [4], where for each plan there is a different level of exposure and risk. This paper focuses on evacuation planning for reducing the exposure risk components and then the actions on the components of a transport system, including [5]: material actions that modify the physical asset of transport infrastructures; immaterial actions that regard, from one side, the Information and Communication Technologies (ICT) [6–8] and, from another side, education, training and exercises of managers and users [9]; management actions for organising transport systems in evacuation conditions [10, 11]; equipment actions that regard means and tool for performing an evacuation.

This paper focuses on the immaterial actions aimed at increasing preparedness with training and exercise actions. These actions contribute to reducing distances between the planned configuration P_{min} and the real implementation when disaster occurs. In this context, training and exercises play a relevant role because their implementation increases awareness of people and managers about the planned procedures for performing an effective evacuation (outcome) and reducing exposure (final goal).

According to Russo and Rindone [9], the implementation of a generic exercise's activity (T_j), produces effects in terms of exposure, quantifiable with the variable $E(T_j)$. The expected outcome of each activity T_j is the awareness enhancement of managers and users involved in the risk situation, tending to reach the exposure level planned with P_{min} and quantifiable with the variable $E(P_{min})$. The exposure reduction contributes to reducing the number of direct and indirect people affected by disasters, in line with SDG targets (see for instance the SDG target 11.5 and related indicators 11.5.1).

In this context, the paper offers the following research contributions:

- a methodology to evaluate the reduction of exposure through training and exercise actions;
- an overview of the possible training and exercises for experimenting with the planned actions.

After this introduction, the paper has three sections. Section 2 presents a methodology for specifying actions that contribute to risk reduction. Section 3 presents some experimental indicators for measuring the contribution of exercise and training actions to risk reduction. Section 4 gives quantitative values for some implementations with final remarks and further developments of the research.

2 A Method for Specifying Actions for Risk Reduction

2.1 Actions for Each Scenario

Reducing exposure is a key element for reducing risk. As seen, exposure can be reduced directly by adopting and implementing appropriate evacuation plans.

To obtain the expected results in the evacuation plan, it is necessary that in the time that elapses between the extension of the plan and the occurrence of the event and therefore of the effects, various exercise and training activities must be carried out. This time is indicated with Δ.

Scenario S is defined by the generic natural or man-made event and by the effects, resulting from the event, on the population, fixing the probabilities of occurrence and vulnerability. In dangerous events, different occurrence levels can be considered from earthquakes to floods and tsunamis (natural), from terrorist attacks to transportation of dangerous goods (man-made).

We indicate with E_0 the aggregate exposure value in ordinary conditions of supply and demand of plan P_0, with E_{min} the minimum exposure value of plan P_{min}, both calculated in the generic risk scenario S by a "what if" planning process, through a system of TSM models.

It is assumed to perform different actions of training and exercise in time period Δ.

Each action affects different subjects and can be developed in different places and at different times (inside Δ) with different managers and different users. It is assumed that the different actions can be identified and that the results of the actions in terms of exposure reduction are independent.

Given a generic scenario S it is possible to specify the general actions present in the literature and in practice for scenario S. Thus, for each scenario S a set of nominally defined actions can be defined in the vector $\mathbf{a}^S$.

$$\mathbf{a}^{\mathbf{S}} = (a_1^s,\ a_2^s,\ \ldots,\ a_{k,}^s \ldots,\ a_n^s)$$

where $a^s{}_k$ is the generic action k to implement for the risk defined by scenario S and n is the total number of actions you want to implement.

As seen in Sect. 1, in the scientific and technical literature, different actions are proposed.

A first problem that arises is that each State specifies these actions differently in its legislation by associating different names.

A second problem, previously mentioned, is that in different States the focus is more on the actions that can be implemented "after" the event. In other States, much importance is given to actions that can be implemented "before" the event. In this second group there is the US.

A third problem is that the actions defined in the regulations of each State, often have overlapping activities, so it is not possible to attribute the results in terms of exposure reduction, to one or another action.

It is therefore necessary to recall the names of the most widely used actions in the "before" approach present in the literature and in the regulation, having to propose here advanced definitions and examples, in order to guarantee the previously introduced hypothesis of independence of the results. It is therefore necessary to identify the central nucleus of each action in order to create a clear separation between the results of the different actions and to obtain specific indicators.

2.2 Training and Exercises Indicators of Exposure Reduction

The theme that arises is to identify a set of indicators that can enable the measurement of exposure reduction and that can be applied in whole or in part to the different actions of exercise and training.

It is necessary that the values of the indicators can be estimated before and after the action is carried out in order to highlight the contribution that the specific action makes to reducing exposure.

It follows therefore that a vector of exposure indicators can be specified whose values can be calculated before and after the implementation of a^s_k generic action.

It is possible to define a function $g_h(\cdot)$ that allows the calculation of the generic indicator e^s_h, based on the effects of the generic action k:

$$e^s_h = g_h\left(a^s_k\right) \tag{1}$$

where the generic e^s_h indicator, of the $\mathbf{e_s}$ vector, is estimated leaving from the effects of the a^s_k action.

Based on Eq. 1 it is possible to define a vector function **g** whose values represent the identified indicators.

By introducing the hypothesis of independence of the results of the different actions and defining an aggregate function of exposure given by the combination of the different indicators it is possible to estimate an exposure level "before" the action:

$$E^s_{before} = f\left(\mathbf{e^s}\right) = f(g\left(a^s_1,\ a^s_2,\ \ldots,\ a^s_k = 0,\ \ldots,\ a^s_n\right) \tag{2}$$

where

$f(\cdot)$is the aggregate exposure level function;

a^s_k is the activity k that you want to implement, and that therefore conventionally is indicated as zero in the before condition;

a^s_1, a^s_2, a^s_n, are the activity-related values that have been, or will be implemented in the future but are not implemented at this stage.

In the same way, it is possible to calculate the aggregate function "after" the implementation of the action:

$$E^s_{after} = f\left(\mathbf{e^s}\right) = f(g\left(a^s_1,\ a^s_2,\ \ldots,\ a^s_k \neq 0,\ \ldots,\ a^s_n\right) \tag{3}$$

with the same meanings previously defined, where only a^s_k for changes precisely because it is the action implemented.

It is possible to exemplify the formulations introduced, assuming that the indicators defined by the vector $\mathbf{e^s}$ are all decreasing and also assuming that the aggregate value of E^S both before and after, is given by a function f ($\mathbf{e^s}$) defined by an algebraic sum. It is possible to exemplify the functions with the hypotheses:

- the indicators defined by the vector $\mathbf{e^s}$ are decreasing as exposure decreases;
- the decrease of each indicator h relative to the implementation of the action k in scenario S, is indicated with d^s_{hk};
- the aggregate value of E^S is given by an algebraic sum of the (decreasing) indicators.

In these hypotheses in whichever state of advance of the actions, from the approval of the plan (no implemented action) forward results:

$$E^S = \sum_{hk} d^s_{hk} \tag{4}$$

The value of Eq. 4 can be calculated:

- for the different actions;
- for the different advances that can be made for the same action;
- in the conditions before and after the implementation of all the action or only part of the action.

More complex functions than Eq. 4 can be used, but the expression considered has both the ability to be easily implemented and the ability to be easily checked in the results.

The methodology presented in this section can be applied to any system of actions proposed by the generic State. One of the most integrated share systems is the one developed in the US [12].

3 Experimental Indicators of Exercise and Training Actions to Risk Reduction

3.1 Class and Characteristics of Activities

Different States have produced procedures for exercise and training. However, the most complete structure present in the literature seems to be the one developed in the US [12]. The same fact of being the most present in the literature confirms that the US framework is the most capable of guaranteeing, to date, the best preparedness.

The central theme of all the actions that develop in the preparedness phase is how a virtual environment with respect to the risk (in the sense that the real event did not happen) can allow the increase of knowledge in all the subjects involved: from the casual and systematic users of the study area to disaster managers of various levels of responsibility.

For each exercise and training activity to be carried out in virtual conditions, defined by any State, the main characteristics to be studied are (Fig. 1):

- the *capability*, evaluated as the ability, or the capacity, to intervene in real conditions to reduce exposure, and therefore the possibility of expressing an indicator of pursuit of the reduction objective;
- the *complexity*, evaluated as the quantity and type of actors involved in the specific activity.

In the methodological hypotheses made and following the two main characteristics identified above, it is possible to introduce an aggregation into two main classes of all the implementable actions.

The first class is defined in a homogeneous way by the activities that can be carried out in an enclosed and indoor environment and which do not require all the real environments in which the effects of the scenario considered can evolve. The main focus of this class is given by the discussion which is developed in various ways and with material and immaterial tools available. They are therefore usually defined as *discussion-based* activities. In these activities, complexity evolves with the growth in the number of actors present, while capability evolves with the specific ability to reduce exposure. In the US

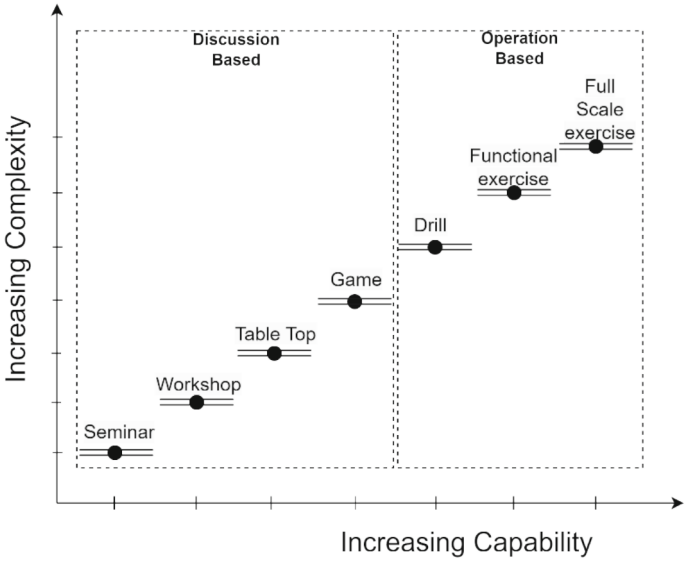

Fig. 1. Classes of exercises

approach, four actions are identified, which can be implemented with different levels of complexity: seminars, workshops, tabletop exercises, games.

The second class is homogeneously defined by the activities that must be carried out in the real environment in which the effects of the scenario considered take place. The focus of this class is given by the operations which are organized in various ways and with various material and immaterial tools available. They are therefore usually defined as *operation-based* activities. Even in these activities, complexity evolves with the growth in the number of actors present, while capability evolves with the specific ability to reduce exposure. In the US approach, three main actions are identified, which can be implemented with different levels of complexity and with the participation of different classes of actors: drills, functional exercises and full-scale exercises.

3.2 Discussion-Based: Seminars

A seminar is a training activity based on the development of an informal discussion about existing plans and procedures. For these uses, discussion-based exercises are exceptional tools for familiarizing organizations and personnel with current or expected capabilities. The seminar is designed to orient participants to familiarize themselves with new or updated plans, policies, or procedures (e.g. a seminar to review the transit agencies' roles in evacuating a group of schools). Seminars focus on the defined evacuation procedures and the case studies. The seminar involves a small group of actors playing a relevant role in a potential emergency situation comprehending emergency managers and citizens. The seminar is characterized by limited interactions between the presenter (PR) and the audience (AU). The communication is only one direction from the presenter to the audience. The activities of a seminar are "lecture-based" and consist of the presentation

of the plan finalized to review of planned actions and procedures. The main output is a review report that indicates the proposal for improving the plan contents. The results of a seminar constitute the starting point for the next exercises or training actions. After a seminar, it is possible to perform qualitative evaluations of the planned emergency procedures.

The Economic Commission for Latin America and the Caribbean (ECLAC) of the United Nations illustrates the main results of an evaluation of seminar activities aimed at orienting policymakers and professionals involved in disaster risk management [13].

A reference indicator for evaluating the reduction in exposure produced by a seminar for the scenario *s* can be given by:

$$e^{S}_{sem} = \textit{time needed for the individual to acquire the plan documentation}$$

The specific indicator can be evaluated with respect to the different hierarchical levels of disaster management [14]. The indicator can also be calculated for different types of users belonging to the population.

The indicator thus specified is easily scalable with respect to the number of participants in the generic seminar. Assuming that the final target is the N_{sem} quantity of managers and users, the indicator has the characteristics defined above capability and complexity.

3.3 Discussion-Based: Workshops

A workshop is a training activity based on the development of interactive discussion similar to a seminar. Compared with a seminar, the main difference consists in the final output which is produced as a draft plan or policy (e.g., a Training and Exercise Plan). The realization of a workshop implies an interaction between organizations (PR) and participants to obtain feedback from the audience (AU) about planned actions and procedures. In this case, there is a two-way communication. The main aim of a workshop is to obtain qualitative evaluations of the planned emergency procedures and their perception from the audience.

Sometimes, seminars and workshops are named "orientation exercises" indicating the actions with the lowest level of complexity, involving the minimum quantity of resources. The main aim is to review and validate existing plans or plans under development, by means of simulation exercises as a part of the preparedness process [15].

A reference indicator to evaluate the reduction in exposure produced by a workshop for the scenario *s* can be given by:

$e^{s}{}_{work}$ = *time needed for the subject to produce the documentation for the official information to be transmitted during the event*

The specific indicator can be evaluated with respect to different hierarchical levels of disaster management. The indicator is calculated both for those responsible for the overall evacuation of the area and for those responsible for the evacuations of individual buildings which perform different functions.

The indicator thus specified is scalable with respect to the number of participants in the generic workshop. Assuming that the final objective is the N_{wor} quantity of managers participants in the workshop, the indicator has the capability and complexity characteristics defined above.

Gwynne et al. [16] propose an "evidence-based" methodology for assessing evacuation drills, also in relation to the application of emergency technologies.

3.4 Discussion-Based: Tabletop Exercises

A tabletop exercise (TTE) is a training activity based on the development of an emergency scenario, simulated in an informal setting. The main objective is to assess plans, policies, and procedures experimenting with roles, procedures, and responsibilities in the emergency management system. TTE allows participants to experiment with the decision-making processes and procedures by means of a discussion about the agency procedures, developed along a hypothetical timeline of actions and events, and identify priorities for evaluation during the full-scale exercise. The TTE involves the key personnel in discussing the scenario evolution, attempting to approximate the real emergency situation. Other than the presenter and the audience, there are:

- a facilitator (F) that stimulates the discussion between emergency managers and participants;
- an evaluator (E) that observes the exercise and collects data and information by means of a survey.

The main aim of a TTE is to perform quantitative evaluations about the potential effects produced by the planned emergency procedures. Sometimes, TTE is recommended as a preparative activity of a complex operation-based exercise [17].

A reference indicator to evaluate the reduction in exposure produced by a tabletop for the scenario s can be given by:

$e^s_{TTE,1}$ = *time needed to exchange information between emergency managers in the management chain for starting the evacuation procedures during the event*

$e^s_{TTE,2}$ = *time needed to communicate population the evacuation order*

The proposed indicators evaluate the level of efficiency of communications and information in the evacuation management process. The indicator $e^s_{comm,1}$ refers to the efficiency in the immaterial exchanges in the command chain. The indicator $e^s_{comm,1}$ refers to the efficiency to disseminate information to population about performing the evacuation. Assuming that the final objective is the Δ_1, the available time interval before instant when the threat occurs [10], the minimization of percentage of $e^s_{TTE,1} + e^s_{TTE,2}$, respect to Δ, contribute to minimize the exposure.

Mat Said et al. [18] present the results of a TTE for verifying tsunami evacuation planning in terms of routes, safe zones and warning protocols with the aim to increase preparedness's community.

Skryabina et al. [17] analyze the potential impacts of the exercises in relation to three terrorist attacks occurred in the UK in 2017 (e.g. the Manchester Arena bombing). The results obtained from the performed surveys demonstrated that TTEs exercises have positive direct impacts during a real incident, in terms of response's times reduction and then increased number of saved lives.

3.5 Discussion-Based: Games

A game is a training activity based on the development of a simulation of emergency operations performed by two or more teams (at least composed by only one person), usually in a competitive environment. The game reproduces a realistic and immersive emergency scenario. The main objective of a game is to use rules, data, and procedures designed to represent a real-life situation, derived from an emergency event. Sometimes a game is a combination of Virtual Reality (VR) and Serious Games (SG) performed to expose involved people to emergency scenarios in a virtual context without any real risks [19]. Like the tabletops, a game aims to perform quantitative evaluations with the support of advanced technologies enabled for measuring further variables about managers and audiences.

The indicators to evaluate the reduction in exposure produced by a game for the scenario *s* can be given by:

$e^s{}_G$ = *time needed to evacuate people (or only one person) in the virtual environment*

where $e^s{}_G$ is the registered time during the game to simulate the evacuation procedure. The time can be disaggregated in relation to each phase of the evacuation procedure. Some examples of performance indicators for a game are reported in Chu et al. [20], by referring to an emergency evacuation simulation in a portion of an urban context. The authors simulate the evacuation time of a single building and of a set of neighborhood roads.

Kwegyir-Afful et al. [21] studied the effects produced by simulation in an immersive virtual reality for testing the fire emergency preparedness and response in a gas power plant. The game exercise simulates an evacuation drill in a fire emergency simulation scenario.

3.6 Operation-Based: Drills

A drill is the simplest operation-based training activity based on the simulation of a single function within a single entity (e.g., a civil protection unit conducts a decontamination drill). Drills are aimed at testing and evaluating the performances of the observed function and relative entity. A drill involves people and managers of a single organizational unit, responsible for the tested function. Sometimes a drill exercise can be performed with the support of a mobile application used as an educational tool. Leelawat et al. [22] analyse the results of a drill for simulating a tsunami emergency scenario. The mobile tool is useful for collecting information about changes in the behaviour of the participants and decision-makers, in relation to different inundation scenarios of relative travel choices (e.g. evacuation routes and destinations).

A reference indicator to evaluate the reduction in exposure produced by a drill for the scenario *s* can be given by:

$e^s{}_D$ = *time needed to conclude planned emergency operations performed by managers*

The proposed indicators evaluate the level of efficiency of single functions in the evacuation management process (e.g. decision making, communication, dissemination, evacuation execution, emergency care activation…). The proposed indicator can be measured in a context without a plan, for instance in an ordinary condition, and after the execution of a drill.

3.7 Operation-Based: Functional Exercises (FE)

A Functional Exercise (FE) is an interactive operation-based exercise that simulates the progress of a hypothetical emergency scenario. FE replicates a system in an emergency condition for testing in a real context with the use of resources and equipment. FEs are aimed at validating procedures of coordination, command, and control between various multi-agency (e.g., urban emergency centres, safety office of a public administration). FE evaluates the organization's capacity to respond to an emergency situation, assessing at the same time, the eventual lack of available resources. FE can be propaedeutically, or a full part, to the realization of a Full-Scale Exercise.

A reference indicator to evaluate the reduction in exposure produced by a FE for the scenario *s* can be given by:

e^s_{FE} = *time needed to evacuate a homogeneous group of users (e.g. living in a single building, in a school, or in a portion of the study area)*

The proposed indicators evaluate the level of efficiency of all functions that have to be activated in the evacuation management process (e.g. decision-making, communication, transportation services for vulnerable people, emergency care activation, traffic management, and signalizing …). The proposed indicator can be measured in a context without a plan, for instance in an ordinary condition, and after the execution of a FE.

In 2013 the city of Los Angeles performed a FE to simulate and evaluate the response's capability in the case of a flood. The master scenario comprehends other sub scenarios, including for instance a road accident involving a dangerous good substance. The FE involved all emergency agencies of the city. The After-accident report indicates the strengths and the weaknesses of the involved organizations [23].

3.8 Operation-Based: Full-Scale Exercises (FSE)

A full-scale exercise (FSE) is a complex operation-based exercise that simulates a real emergency scenario, for testing more functions, performed by more organizations and involving more participants. This is the most advanced step of the HSEEP approach. FSE test procedures involve more organizations and disciplines at different territorial levels (e.g., hospitals, urban emergency centres, fire fighters, and emergency services). A FSE is performed in a highly stressful environment, usually conducted in real-time. The main aim is to reproduce as a "mirror" a real incident in order to evaluate the operational capability of emergency management systems. For these reasons, FSE implementation requires a large availability of resources in terms of personnel, equipment, and financial resources [24].

A reference indicator to evaluate the reduction in exposure produced by a FSE can be given by:

e^s_{FSE} = *total evacuation time of the defined population present in the disaster area*

The proposed indicators evaluate the level of efficiency of all evacuation management functions and the performances of the transport system in an evacuation condition [25]. The proposed indicator can be measured in a context without a plan, for instance in an ordinary condition, and after the execution of a FSE.

Lundh et al. [26] analyze the observations of five full-scale exercises performed in maritime transport passenger services.

4 Discussion and Final Remarks

To reduce the consequences produced by an increasing number of disasters on a global scale, it is necessary to plan and implement actions aimed at increasing preparedness. From the presented review, it emerges a difference in approaches to risk management. In the great part of the world, attention regards the actions for facing the "after" disaster situations. After relevant disasters (e.g. 9/11 terroristic attack and Hurricane Katrina) US introduced a standard approach aimed at increasing preparedness with a set of exercises. Evacuation plans play a relevant role in increasing preparedness and reducing risk. However, to increase the level of efficiency and effectiveness of planned actions, it is necessary to experiment with them in a no-stress context. For this reason, the planning process has to include the design and implementation of a predefined set of exercises for increasing awareness of managers and citizens about the planned actions for facing emergency situations. The final aim is to contribute to risk reduction. This paper focused on the evacuation exercises, planned and implemented for reducing exposure components. The paper illustrates the main functional schemes of each type of exercise, both with reference to the discussion-based and operation-based classes. For each exercise, examples of indicators are proposed to measure performance and to evaluate the possible contribution of the exercises to reducing exposure. However, in a worldwide context, there is a limited quantity of exercises experimented in real contexts for putting into practice the evacuation procedures of cities or their portions. Some experiences regard single buildings with a specific reference to the health sectors (e.g. hospitals). The potentialities offered by the interaction between Transport System Models and ICT enable the implementation of different typologies of exercises to collect information and support evaluations about the effects of planned procedures. The paper presents some limits in relation to the definition of targets for comparing the obtained values of the proposed indicators. For each kind of exercise, it is necessary to provide more insight about the modalities to perform the training activities and relative evaluation methods. The research can evolve following different directions. A first regards the designing process of each kind of exercises by defining involved actors (e.g. managers and people), needed resources and evaluation methods. A second regards the possibility to support exercises with emerging ICT tools enhanced with methods and models of TSM. Final research direction concerns the interactions with other scientific research contexts (e.g. phycology or health).

The obtained results are useful for risk managers and public decision takers involved in the evacuation planning process to increase preparedness before an emergency event.

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References

1. CRED, Centre for Research on the Epidemiology of Disasters: Emergency Events Database (EM-DAT). https://www.emdat.be/. Accessed 23 Dec 2023
2. United Nation. UN: Sustainable Development Goals (SDG). https://sdgs.un.org/goals. Accessed 07 May 2023
3. Russo, F., Vitetta, A.: Risk evaluation in a transportation system. Int. J. SDP. **1**, 170–191 (2006). https://doi.org/10.2495/SDP-V1-N2-170-191
4. Russo, F., Rindone, C.: Methods for risk reduction: training and exercises to pursue the planned evacuation. Sustainability (2024). (In press)
5. Russo, F., Rindone, C.: Planning in road evacuation: classification of exogenous activities. Presented at the URBAN Transport 2011, Pisa, Italy June 6 (2011). https://doi.org/10.2495/UT110541
6. Musolino, G.: Methods for risk reduction: modelling users' updating utilities in urban transport networks. Sustainability **16**, 2468 (2024). https://doi.org/10.3390/su16062468
7. Haghshenas, S.S., Guido, G., Haghshenas, S.S., Astarita, V.: The role of artificial intelligence in managing emergencies and crises within smart cities. In: 2023 International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), pp. 1–5. IEEE, Cosenza, Italy (2023). https://doi.org/10.1109/ICT-DM58371.2023.10286925
8. Astarita, V., Guido, G., Haghshenas, S.S., Haghshenas, S.S.: Risk reduction in transportation systems: the role of digital twins according to a bibliometric-based literature review. Sustainability **16**, 3212 (2024). https://doi.org/10.3390/su16083212
9. Russo, F., Rindone, C.: Urban exposure: training activities and risk reduction. Presented at the Sustainable City 2014, Siena, Italy September 23 (2014). https://doi.org/10.2495/SC140842
10. Russo, F., Chilà, G.: Integrated travel demand models for evacuations: a bridge between social science and engineering. Int. J. SAFE. **4**, 19–37 (2014). https://doi.org/10.2495/SAFE-V4-N1-19-37
11. Vitetta, A.: Network design problem for risk reduction in transport system: a models specification. Int. J. TDI. **6**, 283–297 (2022). https://doi.org/10.2495/TDI-V6-N3-283-297
12. US Federal Emergency Management Agency. FEMA: homeland security exercise and evaluation program. https://www.fema.gov/emergency-managers/national-preparedness/exercises/hseep. Accessed 03 Jan 2024
13. ECLAC: Evaluation report of the seminar and training course on disaster risk management and resilience building (2017). https://www.cepal.org/sites/default/files/news/files/lcar2017_1.pdf
14. Rindone, C., Moschella, M.: Experimentation for risk reduction by training: a framework for seminar activity. (submitted to) International Conference on Computational Science and Its Applications-ICCSA 2024 (2024)
15. European Centre for Disease Prevention and Control: Handbook on simulation exercises in EU public health settings – How to develop simulation exercises within the framework of public health response to communicable diseases (2014). https://www.ecdc.europa.eu/sites/default/files/documents/simulation-exercise-manual.pdf
16. Gwynne, S., et al.: The future of evacuation drills: assessing and enhancing evacuee performance. Saf. Sci. **129**, 104767 (2020). https://doi.org/10.1016/j.ssci.2020.104767
17. Skryabina, E.A., Betts, N., Reedy, G., Riley, P., Amlôt, R.: The role of emergency preparedness exercises in the response to a mass casualty terrorist incident: a mixed methods study. Int. J. Disaster Risk Reduction **46**, 101503 (2020). https://doi.org/10.1016/j.ijdrr.2020.101503
18. Mat Said, A., Ahmadun, F., Rodzi Mahmud, A., Abas, F.: Community preparedness for tsunami disaster: a case study. Disaster Prev. Manage. Int. J. **20**, 266–280 (2011). https://doi.org/10.1108/09653561111141718

19. D'Amico, A., Bernardini, G., Lovreglio, R., Quagliarini, E.: A non-immersive virtual reality serious game application for flood safety training. Int. J. Disaster Risk Reduction **96**, 103940 (2023). https://doi.org/10.1016/j.ijdrr.2023.103940
20. Chu, W.C.A., Chan, M.H.E., Cheung, J., Nguyen, H.-O.: Looking back to look forward: setting future research agenda for international business in textiles and clothing industry. J. Int. Logist. Trade **17**, 21–32 (2019). https://doi.org/10.24006/jilt.2019.17.1.003
21. Kwegyir-Afful, E., Hassan, T.O., Kantola, J.I.: Simulation-based assessments of fire emergency preparedness and response in virtual reality. Int. J. Occup. Saf. Ergon. **28**, 1316–1330 (2022). https://doi.org/10.1080/10803548.2021.1891395
22. Leelawat, N., Suppasri, A., Latcharote, P., Abe, Y., Sugiyasu, K., Imamura, F.: Tsunami evacuation experiment using a mobile application: a design science approach. Int. J. Disaster Risk Reduction **29**, 63–72 (2018). https://doi.org/10.1016/j.ijdrr.2017.06.014
23. City of Los Angeles: City of Los Angeles 2013. Functional Exercise. After-Action Report/Improvement Plan (2014). https://ens.lacity.org/epd/eoboldagendas/epdeobagendas21087710_05192014.pdf
24. Roud, E., Gausdal, A.H., Asgary, A., Carlström, E.: Outcome of collaborative emergency exercises: differences between full-scale and tabletop exercises. Contingencies Crisis Mgmt. **29**, 170–184 (2021). https://doi.org/10.1111/1468-5973.12339
25. Chilà, G., Musolino, G., Polimeni, A., Rindone, C., Russo, F., Vitetta, A.: Transport models and intelligent transportation system to support urban evacuation planning process. IET Intel. Transport Syst. **10**, 279–286 (2016). https://doi.org/10.1049/iet-its.2015.0127
26. Lundh, M., Lützhöft, M., Rydstedt, L., Dahlman, J.: Evacuation in practice — Observations from five full scale exercises. WMU J. Marit. Affairs **9**, 137–151 (2010). https://doi.org/10.1007/BF03195171

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