Redesign of a game to prevent exogenous poisoning: adding risks and forms of participation

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Abstract

In 2016, the digital game *Quem deixou isso aqui?!* was launched, a serious game that aims to raise awareness among parents about the risks of exogenous poisoning present in a common household and the main forms of prevention. This article presents the game's redesign project, intending to correct gaps in the original game, adding the risks of accidents with venomous animals and enhancing forms of player participation, among other improvements. With this account of our experience in this project, we intend to contribute to the creation of other serious games for health communication, which consider the game media's potential.

Keywords: health communication, health games, exogenous poisoning, public health, serious games

1 Introduction

Exogenous poisoning in children is a public health problem worldwide, being a frequent cause of demand for care in emergency services during the first years of the child's life. Exogenous poisoning is known as a set of harmful effects resulting from the interaction of a toxic agent with the body, generating an organic imbalance or pathological state. These toxic agents can be toxic plants, venomous or poisonous animals, pesticides, medicines, industrial chemicals, sanitizers, or other household products (Melo et al., 2022; Neiva et al., 2019; Vilaça et al., 2020).

In Brazil, exogenous poisoning is considered an important public health problem, due to its high prevalence rate, leading to an increasing number of children to death (Neiva et al., 2019). Children from zero to four years old are the biggest victims, due to the characteristics that make them more vulnerable. These characteristics are behavioural as well as organic. Children are naturally curious, try things by putting them in their mouths, are physically and mentally immature, have poor taste, are unable to avoid dangerous situations, tend to imitate and repeat behaviors, and have low body weight and small pathway dimensions in their Top airlines. Another important factor is the home itself, with easy access to agents that, although toxic, are used on a daily basis and can be commonly found in rooms. Due to this facilitated access, the presence of adults at the time of the accident often is not enough to prevent the occurrence of poisoning (Tavares et al., 2013).

We understand that accidents occur due to three main factors. The first, mentioned above, cannot be avoided because it is related to childhood itself. The second can be avoided and is related to society, such as the problem of self-medication, inadequate storage of medicines and cleaning products, and lack of knowledge of parents and guardians about toxic products. The third is related to the State and refers to the problem of public policies to avoid self-medication and to control the presentation of medicines and cleaning products, which should not be colorful, attractive, and unsafe (Bochner, 2005).

Recognizing childhood poisoning as an avoidable problem, the intensification of communication for the prevention of toxicological accidents in childhood can be an effective measure to reduce the number of cases. To reduce the problem of the second factor mentioned, it is necessary to invest in prevention activities, with guidance on the packaging of toxic agents and raising awareness among families of the risks of the domestic environment (Tavares et al., 2013).

As part of these prevention activities, in 2016 the game *Quem deixou isso aqui?!* (Who left this here?!) was launched as a communication material on health (see Figure 1). As it is not possible to teach children under five not to expose themselves to the risks of poisoning (Tavares et al., 2013), the best strategy was to have the other members of a family as an audience, such as young people and adults.

Figure 1. Two screenshots from the original game.

In the game, the player does not control the main character, she is a Non-Playable Character (NPC). She randomly circulates the scene interacting with several common objects in Brazilian homes, but which present a risk of poisoning by ingestion. The player's objective is to prevent the character from becoming intoxicated, moving the toxic agents to places out of reach of the child or removing the agents from the character's hand before she becomes intoxicated.

Since its launch, the team responsible for the first game considered that its development had a series of limitations. Due to them, the game did not address the risk of accidents with venomous animals, an important type of exogenous poisoning, and did not allow the player to customize the character of the child he would take care of in the game, an important and consolidated form of enhancing empathy between player and the game character. Among the technical limitations, the main one was the unavailability of a version for mobile applications. Thus, a new project began to create an improved version that corrected these and other shortcomings, earning the name *Quem deixou isso aqui?! De novo!* (Who left this here?! Again!).

The objective of this article is to present the stages of the project for developing the new version of the game. This article is an extended and revised version of the conference paper *Quem deixou isso aqui?! De novo! Redesign de um jogo digital para prevenção de intoxicações domésticas* (Carvalho et al., 2022), published in the Proceedings of the 21st Brazilian Symposium on Games and Digital Entertainment (SBGames 2022).

2 Health Communication, persuasive games and participation

The conception of the new game was mainly based on the field of Health Communication and the concepts of persuasive serious games, procedural rhetoric, and participation.

2.1 Health Communication

This work is inserted in the field of Health Communication, a field of research and development constituted by elements from other fields of knowledge, which are Communication and Health. This means that communication is not approached as a mere instrument for health goals, but participates as an area of theoretical and political knowledge. In this approach to Health Communication, communication cannot be separated from an ethical project of society (Araujo & Cardoso, 2007).

Thus, this work is not about an educational strategy, but a communication strategy regarding a public health issue as a way of communicating health risks and democratizing knowledge to avoid a statistically relevant health problem. The game design was influenced by the concepts of Communication and Health and not the field of Education studies. Although the two fields can be confused because

both deal with the democratization of socially relevant knowledge, the game was not planned as an educational game, inspired by curricular bases, based on knowledge assessment or other principles that can be recognized as proper to Education.

2.2 Serious Games

We conceived *Quem Deixou Isso Aqui?! De novo!* as a serious game, taking into account the concepts of procedural rhetoric and games as a kind of participation and part of a participatory culture. We opted for the approach as a serious game and not more specifically as an educational game because the game was conceived as a communication material. This does not mean that players cannot learn from the game, but it does mean that the game was not as a material that is part of teaching strategies or applications in the classroom, although it can be appropriate in activities within the space of education (Vasconcellos et al., 2017).

Although some authors define serious game as practically synonymous with educational game, we consider "serious game" as a broader category of games designed with objectives other than mere entertainment. This means that we consider so-called educational games as just one of the many possibilities that serious games can offer.

The first definition of serious games predates digital games and defines them as games that have an "explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (Abt, 1970, p. 9). A more current definition of serious game and related to digital games is that of Michael and Chen: "A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment." (Michael & Chen, 2006, p. 17).

However, the "education" category does not accommodate a number of other games that have been categorized as serious games, such as political, religious, artistic and social awareness games. Furthermore, we know that many other alternative terms have already been created for this category (Vasconcellos et al., 2017). Despite this, we maintain the use of the expression serious game and opted for Raessens' definition (2015, p. 246):

> Serious games are games that are designed and used with the intention or purpose to address the most pressing contemporary issues and to have real-life consequences, for the world outside the magic circle of the game as well as for the player of the game, during and after playing.

Regarding game design, we believe that serious games seek to incorporate technical aspects that are close in quality to those of commercial entertainment games. Another concern is that they function as a game in the first place, that is, even if the player does not have the slightest interest in learning about a certain subject, the functioning of the serious game, its rules, aesthetics and narrative must be able to maintain their interest (Michael & Chen, 2006). To ensure these characteristics, another important conceptual basis for the work was the concept of procedural rhetoric.

2.3 Procedural rhetoric

Ian Bogost is a scholar who has focused on the construction of meaning in digital games and particularly in serious games. Treating serious games as persuasive games, Bogost (2007) presented the concept of procedural rhetoric. According to Bogost, digital games, as well as other cultural productions, carry ideological values and ways of representing the world. Thus, we can say that they contain within themselves elements of rhetoric. In fact, as digital games are composed of different media, it is also possible to say that they have different types of intertwined rhetoric. However, there is a unique type of rhetoric in digital games that would be the rhetoric inscribed in their rules or operating procedures. According to Bogost (2007), game rules are expressive themselves and the unique power of digital games is their ability to represent real-world processes in dynamic in-game procedural metaphors that are operated in conjunction with the player's actions.

Making a parallel with the Greek concept of enthymeme, a syllogism that hides one of its premises, leaving the reader with the task of completing the gap to complete the argument, a serious game would have gaps that the player would fill in by interacting with its rules. Each procedural argument completed by the player another would follow and with the completion of all of them, the player would complete the game and the procedural argument, being persuaded. Such persuasion would not primarily come from the text read or the images seen, but from their analysis of the cause and effect relationships experienced in the game (Bogost, 2007).

What follows from this understanding of procedural rhetoric is that the meaning of a game is primarily inscribed in its rules and such a message is apprehended by the player when he interacts with the game through the actions he performs during the game (Bogost, 2007).

In the example of the game *Quem Deixou Isso Aqui?!,* instead of showing the player messages talking about the risks of exogenous poisoning or shocking images of injured children, the game makes the player put himself in the role of an adult in a typical Brazilian home. He must prevent an NPC representing a mischievous child between 2 and 4 years old from picking up a toxic substance and putting it in their mouth. The player must store the substances outside of the child's reach or, if necessary, take them from the child's hands in time for her not to become intoxicated. At the same time, the player must take care of other daily tasks, such as answering the phone or the door.

Dealing with the rules and procedures of the game, the player understand that younger children do not have controllable habits, that there are many dangers that are accessible daily in a regular home, but that there are simple actions to avoid accidents (Vasconcellos et al., 2018).

2.4 Participation

Raessens' concept of games as participation (2005) was considered in order to understand the game as part of a participatory media culture. As a way of dealing with this aspect of digital games, Raessens argues that more than interaction or procedurality, from the players' point of view, participation is the defining characteristic of digital games. In this way, participation would describe not only the act of playing but would qualify the culture that forms around games as a participatory media culture.

Such participation in games would occur in three basic forms or domains: interpretation, reconfiguration, and construction. First, the interpretation refers to how the player perceives the media of digital games in a participatory and socially situated way. Second, reconfiguration consists of the player's act of interfering with game elements in the form of non-linear exploration or in the form of manipulation, which means changing game elements to obtain some effect. Finally, construction refers to the insertion of new elements in the game by the players (Raessens, 2005).

For the new version of the game, these concepts inspired the option for creating a character customization system and the possibility of sharing game images on social media, since these are ways for the player to, in a sense, add elements to the world created in the game.

3   Redesign steps

The team is made up of a game designer, an artist, a programmer and a social media manager. The game designer and the artist are additionally professionals with years of experience in health communication projects at the Oswaldo Cruz Foundation, both PhDs in Information and Communication in Health.

To keep information about the game project shared among team members, a Game Design Document (GDD) was built. The GDD records guidelines common to the UGC (Sarinho, 2017) namely: game concept, game player, game play, game flow, game core and game interaction. The later was complemented with accessibility recommendations.

The GDD was an important instrument for registering the project's conceptualization, which was built by the team and remains as a source of consultation during the development of the game.

Game development steps were coordinated with the help of work schedules visualized and shared among the team with online *kanban* board in the *Trello* app.

3.1 References regarding exogenous poisoning

We selected 24 communication materials on the topic of exogenous poisoning, forms of prevention and first aid published by Vital Brazil Institute and Oswaldo Cruz Foundation (Fiocruz), two leading public health institutions in Brazil. There were nine booklets, eight YouTube videos and seven posts on Instagram. These were materials intended for young or adult audiences, the same audience as the game, and were used as a source for writing the texts for the game.

In addition to technical information about exogenous poisoning, the material gathered was an important source on priorities when communicating the subject and the type of

accessible language to be used with the public. We could see that the communication strategies of the two institutions avoid inducing fear with shocking images and also avoid encouraging people to mistreat or use poison to exterminate venomous animals. These communication materials treat animals as interesting biological species, part of nature, and never as evil villains.

3.2 Entertainment game references

As we believe that serious games should be games that the public enjoys playing, the aim of the searches was not to find serious games about poisoning but to find successful entertainment games to form a repertoire of mechanics and visual styles that could help to improve o create new solutions for the new game.

The original game *Quem deixou isso aqui?!* was inspired by Pixonic's casual game Little Helper, released in 2011 (Figure 2). In the game, players must clean up a dusty, cobweb-ridden house and can plant and harvest flowers. The setting is a Russian country house, and the rewards for working are lovely collectibles representing traditional Russian handcrafted items. Although 4-year-olds can play this game with adult supervision, the target audience for the game's development was 35-year-old women (*Little Helper from Pixonic*, 2012), which was the basis for the decision to style the art for *Quem deixou isso aqui?!*.

Figure 2. Screenshot of *Little Helper*

We conducted qualitative searches for entertainment games for mobile devices in the Play Store, for devices with the Android operating system, and in the App Store, for devices with the iOS operating system. Four games were selected for reference: *Toca Life World* (Figure 3)*, Dr. Panda Town Tales* (Figure 4)*, Animal Restaurant* (Figure 5) and *Adorable Home* (Figure 6)*.

Animal Restaurant and *Adorable Home* target adults, indicating on the Apple Store that they may be unsuitable for children under 12. These two games have colourful and fun artwork, indicating that these artistic directions are not exclusive to children's audiences. In addition to their art, we took their interface features as reference for the new game, in addition to interaction on social networks, identified as important resources to encourage player participation.

Figure 3. Screenshot of *Toca Life World*

Figure 4. Screenshot of *Dr. Panda Town Tales*

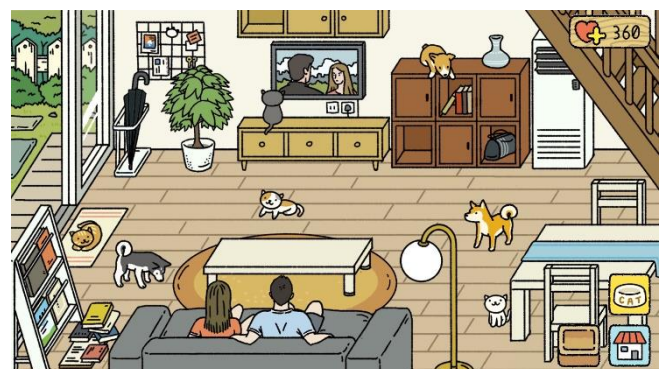
Figure 5. Screenshots of *Animal Restaurant*

Figure 6. Screenshot of *Adorable Home*

3.3 Tests with the original game

The original game was tested by 10 participants whose profiles represented the game's target audience. The participants rated items adapted from the *GameFlow*

Questionnaire (Felix et al., 2018), playing and observing challenge, player skills, control, goals, and feedback. The accessibility recommendations reported by Belli and Alves (2019) for games for mobile devices complemented the test. Thus, during the tests, we observed if the game was perceptible, operable, understandable, and robust.

We analysed the results according to a qualitative approach and revealed problems to be corrected according to Table 1.

Table 1. Test contributions with the original game.

Detected problems	Proposed solutions
Available to play on internet browsers only.	Develop games primarily for mobile devices, keeping an option for web browsers.
Mechanics of clicking, putting it in the inventory and clicking again to deposit it in the locker proved to be unintuitive.	Mechanics of touching and dragging the object anywhere. Click and drag the object in the browser version.
Moving between scenarios with barely visible and not very intuitive arrows.	Game with only one scenario, with all the rooms in the house in the same image.
Players felt the game was too "stressful".	Balance game events for a slower, satisfying environment exploration dynamic.
Duration 3 minutes too long for the stressful gaming experience.	Balance game elements and events for a slower, more satisfying dynamic while maintaining the 3-minute duration.
Arts and texts with low readability.	Make arts to increase size and contrast.
Scoring system that generates an abstract number, with no direct relation to the game's message.	Eliminate scoring and emphasize three different endings: absolute victory, victory with constraint, and defeat.
Text-only social media sharing and score number.	Prioritize the sharing of attractive game images.
Game developed in Construct 2	Develop the new game in Unity, to enable new features.

3.4 Low resolution prototype test

In order to involve experts in the earliest stages of the project, we created a low-resolution prototype (Figure 7). The experts evaluated the prototype according to the setting, characters, threats, rules and game mechanics. The experts were two researchers from Fiocruz and Vital Brazil Institute, with years of experience in research and scientific dissemination of the risks and prevention of exogenous poisoning. Rosany Bochner is a former coordinator of the Brazilian National System of Toxico-Pharmacological Information, and a professor from the Graduate Program in Health Information and Communication. Cláudio Maurício Vieira de Souza is a former Scientific Director of the Vital Brazil Institute, and is PhD in Health Information and Communication by Fiocruz.

Tests with a low-resolution prototype were fundamental to avoiding mistakes in the threat representations. The specialists were also important in planning the hiding places for venomous animals and in the procedures for eliminating the risk of accidents, which do not involve the use of insecticides or sanitizing agents, but only mechanical actions such as removing garbage and using physical barriers, such as lids and protection nets.

Another concern of the specialists was to avoid encouraging people to exterminate animals that do not pose

a risk. One example was the decision to remove the representation of spider webs as an item for the player to "clean up" to avoid spider bite accidents. Spiders that produce circular webs, the most popularly known format in cartoons, do not pose a risk of accidents and the population should not be encouraged to exterminate them.
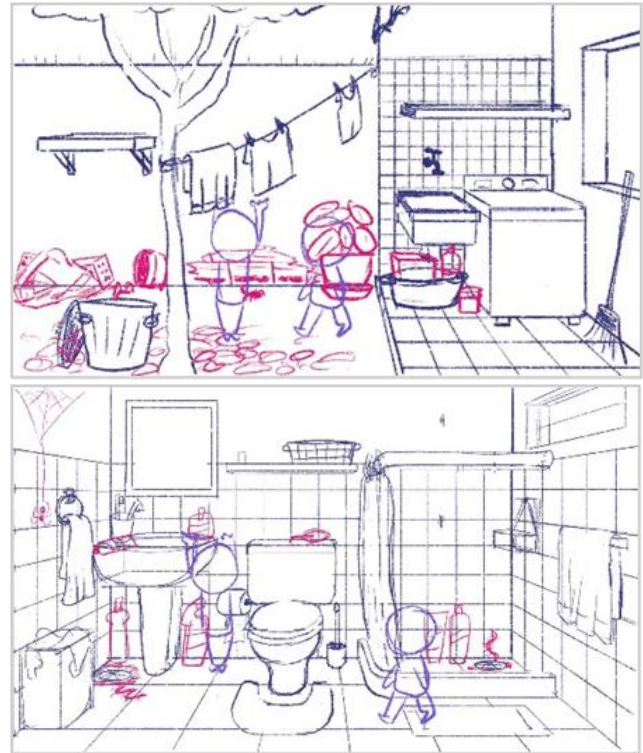

Figure 7. Two screens of the low-resolution prototype

3.5 Arts and texts

Based on tests with the original game, the team decided to create new arts to have greater visibility on mobile devices, taking selected entertainment games as a model for colors and contrast.

The team wrote game texts in simple language, mainly aiming at communicating risks and procedures, rather than scientific dissemination, although this second approach is very common in the communication materials of the institutions involved. The experts reviewed all texts, contributing to the writing. The same procedure was performed with the illustrations of objects, animals and plants.

The illustrations of the scenario and poisoning threats were created with the Affinity Designer software (Figure 8).

Figure 8. Examples of toxic item art

Even in a cartoon style, the representations of product bottles and toxic plants seemed easy to identify the real object. However, to represent the venomous animals, we created the illustrations in a more realistic style, using Procreate® software, in order to ensure a more direct identification with the real animal (Figure 9).

Figure 9. Examples of venomous animal art

We created the game scenario as a continuous image to be touched and dragged on the screen, as a more intuitive way of navigation for the player (Figure 10).

Figure 10. Snippet of scenery

All illustrations were also tested using the color blindness simulator Coblis (Flück, 2006), as a way to ensure accessibility for this visual atypia. We tested the game's artwork in four different types of color blindness simulation to ensure that it had sufficient contrast and readability: Protanopia, known as red-blind view (Figure 11); Deuteranopia, known as green-blind view (Figure 12); Tritanopia, known as blue-blind view (Figure 13); and Achromatopsia (Figure 14), known as monochromacy view (Salih et al., 2021).

Figure 11. Protanopia simulation

Figure 12. Deuteranopia simulation

Figure 13. Tritanopia simulation

Figure 14. Achromatopsia simulation

As in its original version, the game starts with the character Aninha, but she was redesigned to follow the same style as the scenario and also to make possible the new character customization mechanic (Figure 15).

Figure 15. Custom character possibilities

We designed these new possibilities to enhance player participation through representativeness. We hope that players customize the main character to look like their respective children in real life, increasing empathy and willingness to care for the character, also encouraging the sharing of screenshots from the game.

3.6 Interface design and development

For the interface design, we created a prototype on the *Figma* collaborative design platform. The first prototype was developed in medium resolution (wireframe), prioritizing tests with the functionalities and flows between the interface screens. Afterwards, the wireframe elements were replaced by high-resolution color images, which also underwent testing and adjustments.

Development was completely redone using the *Unity* game engine, to enable new features, such as the possibility of adding language-switching options, and to facilitate new updates that the game may receive in the future. Development started as a prototype using images as placeholders, which were frequent tested. Gradually, we replaced the temporary images by the definitive illustrations.

To improve player participation, the game starts with a character customization system, in which player can change skin colors, hair, choose hair textures and hairstyles, clothes and shoes (Figure 16). The player can also share a screenshot showing the customized character directly from the game to social media as an option to participate and promote the game.

Figure 16. Character customization screen

In addition to keeping products out of the reach of children, there are new game mechanics: the player must clean the environment, throw out the garbage, fix holes in walls and floors, and cover trashcans and drains to prevent the appearance of venomous animals. If the player neglects one of these preventive actions, after a few seconds there is a possibility that a venomous animal will appear in its place.

Figure 17. End of game screen for accident with venomous animal

The animal randomly walks around and, if it eventually touches the child, the child is automatically envenomed and the game session ends (Figure 17). This endgame screen identifies the animal that caused the accident and the main recommendations to be followed in a real-life accident. We avoid portraying the animals' behaviour as aggressive or intentional, as envenoming by venomous animals are categorized as accidents and not as attacks. Remembering that there is no interest in causing panic or encouraging people to exterminate all the animals they encounter in real life.

There are five possibilities for endgame screens. Among the three endings possibilities of poisoning, there is an ending with information about accidents with venomous animals (Figure 17), one with information about ingesting toxic products and another with information about toxic plants.

As pointed out after testing the original game. We decided to replace the numerical score result originally in the first game with feedback via endgame screens. One screen represents an absolute victory, in which the player managed to take care of the child, the house and prevent her from becoming intoxicated (Figure 18).

Figure 18. Absolut victory endgame screen

As a secondary game mechanic, eventually the child asks for a specific food. The player should look for it and deliver it to the child. If the player manages to prevent the child from poisoning himself but does not respond to a food request, the game ends with a "partial victory" screen showing the child going to sleep sad (Figure 19).

Figure 19. Partial victory endgame screen

3.7 Dissemination

The project maintains accounts on the main social media: Facebook (www.facebook.com/quemdeixouissoaqui), Instagram (www.instagram.com/quemdeixouissoaqui) and Twitter (twitter.com/QuemDeixou_jogo). We use these

accounts to publicize the progress of the game's development project and also to publicize issues relevant to collective health about exogenous poisoning addressed in the game, always using concept art, game illustrations or game screenshots, depending on the stage of development.

Each post is designed primarily for Instagram's own format (Figure 20), with captions describing the images to enable the use of a screen reader as an accessibility feature. The same images and texts are used for the publications on Facebook and Twitter.

Figure 20. Cards for promotion on Instagram

As in the game, publications on social networks address the topic in a fun way, without resorting to shocking images of accidents or encouraging panic in relation to venomous animals.

During the work of launching posts on social media, we tried to form a community of followers following and participating in posts from other institutions and profiles that dealt with the subject of exogenous poisoning. However, we noticed that the number of followers and overall engagement remained low, signalling that it is necessary to hire boosting services to ensure audience reach.

4   Concluding remarks

The new game *Quem Deixou Isso Aqui?! De novo!* represents a series of improvements in relation to the previous game. In addition to adding the theme of venomous animals, the current project is incorporating aesthetics and interface elements inspired by successful entertainment games, in order to enhance the players' experience. We hope to achieve a more satisfactory gameplay, in which the player has more time to explore the game environment and interact with procedures for prevention of accidents that can happen at home.

In this new game, we added accidents with venomous animals as an important problem to be communicated. We also added new game experiences that we hope will encourage player participation, like as character customization and sharing game images on social media. We recreated all the arts, in order to better adapt the game to mobile platforms and increase its accessibility. We also created a more robust game structure that would make it easier to add new features or translate it to other languages in future versions. In addition to publicizing the development of the game, we hope that the posts on social media will help to encourage future sharing of game footage by players.

As future research, we intend to make two different studies to evaluate the game involving its target audience. We will submit these projects to the Research Ethics Committee of the Escola Politécnica em Saúde Joaquim Venâncio (EPSJV). The first will consist of a quantitative usability study and the second will be a qualitative public reception study.

In the usability study, the System Usability Scale (SUS) test will be applied, and at least 40 participants will play the game and then respond to the SUS survey.

Among these participants, we will recruit at least eight to participate in the second study, consisting of focus groups to discuss the experience. The objective will be the analysis of the production of meanings about exogenous poisoning after game sessions. In this way, the project will be extended with new possibilities for research, publications and game improvement.

During the development of this new version, we collected other ideas for a new future version to be realized in a future project. Among these ideas, we list other risks for young children indoors, such as accidents with sharp or pointed objects, falls, suffocation, burns and accidents with the electrical network and home appliances. Such inclusion will require further research on these risks and the involvement of other subject matter experts. We also plan to implement new game mechanics suitable for the adult audience, such as the possibility of customizing the house, redecorating the scenarios by mobility or replacing furniture or decorative objects, in order to make the experience of exploring environments more satisfactory and participatory.

With this account of our experience in this project, we intend to contribute to the creation of other serious games for health communication, which consider the game media's own potential.

Acknowledgements

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