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Information visualisation as a resource for popularising the technical-biomedical aspects of the last Ebola virus epidemic: The case of the Spanish reference press

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Abstract
This study explores the role that information visualisation played in the popularisation of the technical-biomedical aspects of the last Ebola virus epidemic, the most devastating to date. Applying content analysis methods, the total population of information visualisations ($N = 209$) was coded and analysed to identify topics, and to define features and identify patterns in the images. The corpus was based on the record of articles with graphics appearing in five Spanish reference newspapers from 22 March 2014 to 13 January 2016, the start and suppression of the epidemic, respectively. The results suggest that information visualisation was a key factor in the popularisation of the epidemic's technical-biomedical aspects, as well as contributing actively to construct, in the words of Myers, a narrative of nature.

Keywords
content analysis, Ebola, infographic, information visualisation, science popularisation

1. Introduction

In 1920, the Swiss-German artist Paul Klee wrote in his *Creative Confession*: 'Art does not reproduce the visible; rather, it makes visible'. To paraphrase him, one could say that information visualisation (which is also referred to as 'graphic' or 'visual representation') allows journalists not so much to reproduce the visible as to make visible what is not. Indeed, by means of information visualisation, it is possible to reveal patterns and relationships that are not always evident in a dataset, to represent entities (viruses, bacteria, organs, the internal structure of artefacts, etc.) and to describe molecular processes, biological cycles and the sequential stages of natural phenomena or technical achievements which would not otherwise be visible, that is, comprehensible. Visual communication in journalism can be understood as the activity of producing visualisations of data and information graphics or infographics. As a matter of fact,

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infographics has become one the best resources for communicating scientific information to both specialists and laypersons (Frankel and DePace, 2012; Hornmoen, 2010; Silletti, 2015; Trumbo, 1999). Infographics is a journalistic tool that cannot be reduced to something merely ornamental, but should rather be conceived as a singular and effective resource for constructing and popularising certain knowledge among wide audiences. It is important to stress that images and headlines are the first elements of journalistic texts of which readers take note, as indicated by eye-tracking studies (see Holsanova et al., 2006).

It is striking, however, that until recent decades, scholars have not paid due attention to science-based images destined for both peer communications and dissemination and public consumption (Hüppauf and Weingart, 2008). However, the mass media constitute one of the most characteristic extra-scientific domains in which scientific information and knowledge is consumed in various visual formats.

In spite of the fact that communication models recognising that audiences are heterogeneous and active and need to be heard are postulated in academic circles, the truth is that communication praxis in the written press is still anchored, in many respects, in the traditional model of dissemination of science information or science popularisation (see, for example, Schäfer, 2011; Summ and Volpers, 2016).

This article addresses the analysis of information visualisations with a huge potential for popularising scientific-technical knowledge. Specifically, it explores the role that they played in the popularisation of specialised knowledge (technical-biomedical aspects) pertaining to the last Ebola virus epidemic in the Spanish reference press.

The epidemic outbreak of the Ebola virus disease (EVD) in Guinea Conakry in December 2013 has been the most devastating to date. From there, the virus spread to other African countries and, for the first time since being identified in 1976, reached Europe. On 7 August 2014, the Spanish government repatriated the missionary Miguel Pajares, who had become infected in Liberia. Teresa Romero, one of the nursing assistants who cared for Pajares at Carlos III Hospital, Madrid, fell ill two months later, thus becoming the first person to be infected by the virus in Europe. The arrival of the missionary from Liberia marked the beginning of a comprehensive coverage of EVD in Spain's major national newspapers.

2. Review of the literature

Information visualisation

Visualisation is a blanket term that refers to any visual representation designed for the purpose of communicating, analysing, exploring and discovering patterns in information (Cairo, 2016). It is a singular 'functional art' that combines words and images with a varying degree of abstraction (Cairo, 2013). In the specific case of journalism, information visualisation is a powerful and convenient tool for constructing events or phenomena and making them understandable by means of *figurative* graphics (illustrations, photographs, drawing, diagrams, maps, etc.) and *non-figurative* ones (statistical graphs or data visualisations). The former represent physical phenomena and retain certain similarities between the object and its visual representation, while the latter strike a conventional balance between the object and its visual representation (Cairo, 2013). Both types of graphics can form an integral part of infographics. Therefore, information visualisation is particularly important because it serves as a *support for understanding*: it not only allows us to describe and explain objects, complex processes and events, but also helps us to discover, behind a chaotic dataset, 'connections, constants, patterns not always obvious to the casual eye which, if they were not represented visually, would remain hidden from the reader' (Cairo, 2008: 29; see

also Kirk, 2012). The combination of iconic and verbal elements offers a greater explanatory power than mere words and images on their own. Thus, information visualisation, in addition to providing a certain degree of aesthetic pleasure, facilitates data analysis.

Data visualisation can be defined as the representation of numerical values (abstract information) by means of charts, graphs and tables, in such a way that raw data are transformed for their graphic presentation. It can be a very efficient way of showing a large set of numbers in a limited space (Krum, 2014). For its part, an infographic, acronym stemming from the expression 'information graphic', displays simultaneously a large quantity of data and information about the history of an event, phenomenon or issue (Dur, 2014). It is usually made up of different parts (figurative and non-figurative graphics, as well as written text) united by thematic juxtaposition to convey one or several specific messages and to provide an explanation and context. According to Krum (2014: 6), 'data visualizations by themselves are no longer considered to be complete infographics but are a powerful tool that designers often use to help tell their story visually in an infographics'.

The term 'data visualisation' is useful for referring to those visual representations that are produced in an algorithmic fashion (they allow for some customisation, but their basic design is completely computerised), can be reused easily with different datasets and are aesthetically minimalist and rich in data (they can handle large volumes). On the contrary, infographics is a useful term for referring to manually produced illustrations that, as a result of this process, present a personalised treatment of information, are specific to a dataset (they cannot be reused with others), are aesthetically rich (with a strong visual content keyed to engaging readers and sustaining their interest) and are relatively poor in data (since each piece of information must be coded manually) (Iliinsky and Steele, 2011). Both are *multimodal texts*, to wit, coherent entities of semiotic interaction in which each mode, the visual and the verbal, plays a specific and balanced role (Kress and van Leeuwen, 2006). In other words, they not only exhibit additional information, but also allow readers to explore different levels of reading and establish less obvious data connections which, otherwise, would not be so clear.

Classification of information visualisations

Given the wide range of existing graphics, hierarchical classifications and taxonomies have proliferated (Desnoyers, 2011; Lester, 2006; Lohse, et al., 1994; Racine, 2002; Valero et al., 2014). It has been assumed here that data visualisation and infographics are two different ways of visualising information, although the former can be included in the latter. Moreover, the typology proposed by Lester (2006) has been adopted and adapted. His basic idea is to differentiate between 'statistical infographic elements' and 'non-statistical infographic elements'. The first group includes graphics displaying a scale which contains concise and comprehensible numerical information in order to highlight data trends, which if presented in a purely verbal form could escape readers. The most important are numerical data tables, line charts, pie charts, bar charts, area charts, bubble charts, radar charts and scatter plots. Quantitative or statistical maps ('data maps', in the terminology of Lester), namely, maps that combine geographical information with quantitative data (choropleth maps, dot maps, proportional symbol maps, isoline maps and cartograms), also belong to this first group.

The second group encompasses qualitative graphics: drawings, 2D and 3D illustrations, diagrams, flowcharts and floor plans. Diagrams are widely used in journalistic information. Indeed, the most eye-catching infographics usually involve their use (Lester, 2006). There are two classes: (1) structure diagrams, which statically describe a physical object and (2) process diagrams, which describe the interrelations and processes associated with physical objects (Lohse et al., 1994). These diagrams are normally accompanied by diverse visual devices (e.g. the enlargement

of some detail of the representation, presentation of different perspectives, use of colours, arrows or pictograms) and verbal ones (e.g. labels, callouts, explainers, etc.), which help readers to understand the information (López-Manjón and Postigo, 2014).

This second group also includes, on the one hand, text-based graphics: fact boxes which 'contain a series of statements that summarize the key points of a story' (Lester, 2006: 188); timelines which allow for the visualisation of the most significant events of a phenomenon or history along a horizontal or vertical line on which relevant dates are indicated (Lester, 2006) and schemata which arrange information by means of arrows or opening curly brackets, and, on the other, qualitative maps ('non-statistical maps'), namely, maps that are not based on numerical data (locator maps, explanatory maps and chorochromatic maps). Nonetheless, locator maps (with or without a scale) are considered here as *mixed* (qualitative and quantitative), since on occasion, they contain numerical data.

Furthermore, there is a third group of *hybrid maps* that simultaneously provides qualitative and quantitative data (chorochromatic-proportional symbol maps and chorochromatic-dot maps).

And, lastly, there are flow maps that, by means of arrows (proportional or not to a numerical quantity), represent the movement of objects, animals or people from one place to another.

Epidemic diseases in the mass media

Since the 1980s, medicine and health-related issues have dominated the public debate on science (Bauer, 1998). In recent decades, scholars have shown a growing concern for the coverage that the media dedicate to emerging infectious diseases that, on occasion, lead to epidemics. In addition to EVD, media coverage has focused above all on the HIV/AIDS epidemic (see Mayer and Pizer, 2005), H5N1 avian influenza (see Hellsten and Nerlich, 2010; Koteyko et al., 2008), the H1N1 influenza pandemic (see Lee and Basnyat, 2013; Wagner-Egger et al., 2011) and the SARS epidemic (see Ding, 2009; Lewison, 2008; Wallis and Nerlich, 2005).

EVD, as with other types of epidemics, is a technical-biomedical problem (e.g. epidemiology, vaccine development), as well as a socio-economic (e.g. prevention and research costs, negative impacts on the affected populations) and political one (e.g. resource allocation, spending on vaccines and treatments) (Hellsten and Nerlich, 2010). The public health crisis arising from the most recent Ebola epidemic claimed 11,000 lives and had dramatic socio-economic consequences for the African countries concerned. In the Spanish case, the attribution of responsibilities to the different administrations involved in the political management of the crisis and the socio-economic repercussions of the health alert were, at the time, hot topics in the press. While the political and socio-economic aspects of the epidemic tended to be better understood by wide audiences, its scientific-technical explanation might have seemed more difficult to grasp. Information visualisation had apparently a lot to do with the popularisation of the epidemic's technical-biomedical aspects.

A number of previous works have focused on the coverage of the Ebola outbreak of 1995 in Zaire (Ungar, 1998), the representation of EVD in the British media as a remote disease (Joffe and Haarhoff, 2002), the nature and scope of the Ebola epidemic in the United States (Basch et al., 2014; Kane, 2015) and Spanish (Barberá and Cuesta, 2015; Revuelta et al., 2015) written press, the institutional communication of the crisis in Spain (Micaletto and Gallardo, 2015), the metaphoric discourse of the disease and its victims in the American liberal press (Trčková, 2015) and the rhetoric employed by the World Health Organisation (WHO) and its impact on the propagation of the virus (Condit, 2015).

Despite the capacity of graphic representations to communicate the different technical-biomedical aspects of EVD, there is a dearth of literature in this respect. Welhausen (2015) is the only author

who has addressed the analysis of visual strategies in risk perception with regard to EVD. Hence, this work intends to fill that void.

The use of visual aids to communicate other technical-scientific topics

Only a few studies have paid due attention to the role played by visual aids, besides photographs, in the news coverage of other technical-scientific topics. Some authors have analysed the contribution of visual aids to the popularisation of technical information on climate change in the British (Smith and Joffe, 2009), Canadian (DiFrancesco and Young, 2010) and US press (Rebich-Hespanha et al., 2015). By the same token, it has been observed that for communicating environmental information, the messages included in infographics are more dissuasive than others without visual aids (Lazard and Atkinson, 2015).

There are also several studies that focus on the effects of graphic representations on audiences in the field of health risk communication, in general (e.g. Ancker et al., 2006; García-Retamero and Cokely, 2013; Lipkus, 2007; Stone et al., 2015), and as regards breast cancer risk, in particular (Occa and Suggs, 2016; Schapira et al., 2006). The literature on visual aids for displaying epidemic information is practically non-existent: Wong et al. (2013) have studied the influence of interactive maps on the perception of the H1N1 flu pandemic; for her part, Shin (2016) explores the strategic and visual characteristics of infographics used by health organisations and news media for disseminating epidemic information.

3. Research questions

Since there are no previous studies of the topic, there are currently no data on core issues, such as how frequently information with technical-biomedical content is visualised in the written press. Thus, the first research question was as follows:

> *RQ1*. What is the proportion of technical-biomedical-related information visualisations with respect to the total number of visualisations of Ebola-related information published during the study period?

The suitableness of information visualisation for disseminating scientific information and popularising specialised knowledge begged the following two questions:

> *RQ2*. What technical-biomedical content associated with the Ebola epidemic is visually represented? How is this content distributed depending on the newspaper?
>
> *RQ3*. Is there any relationship between information visualisation and technical-biomedical content variables?

Expert information sources play a relevant role in disseminating scientific information, framing specific interpretations and giving meaning to messages related to public health (Nelkin, 1995; Rock, 2005). It was thus necessary to identify the sources employed by the media to cover the EVD epidemic:

> *RQ4*. What sources have provided journalists with information on EVD for their visual representations?

Moreover, it is interesting to determine the relationship between the graphics and the journalistic texts in which they were inserted. In addition, the presence or absence of references in the written texts and/or in the graphics themselves to their representative nature could provide insights into the type of narrative structure underlying the discourse on EVD (see Myers, 1990). To this end, the following questions were posed:

RQ5. Is there any link between the infographics and the texts in which they are inserted? If so, are there any significant differences between the link that an individual graphic establishes with the text in which it is inserted and that established by a graphic visual representation in an infographic?

RQ6. Are there any references to their representative character in the written text or in the information visualisation itself?

Based on the syntactic structure of the headlines of the visual representations, the communication purpose of Ebola-related information visualisations was explored.

RQ7. What syntactic structures do the headlines of the graphics adopt?

4. Materials and methods

In order to answer the research questions, a content analysis was performed on the total population of information visualisations relating to technical-biomedical issues arising from the last Ebola epidemic in the Spanish reference press (*El País, El Mundo, La Vanguardia, ABC*, and *El Periódico*).

The study period lasted from 22 March 2014 (when Guinea Conakry officially declared that there had been outbreak in the country) to 13 January 2016 (when the WHO officially declared an end to the epidemic).

Using the databases of the aforementioned newspapers, all the journalistic texts containing the keyword 'Ebola' were reviewed, extracting those that included graphics. After excluding those texts with graphics that were not directly related to the epidemic's technical-biomedical aspects (29 articles), 93 were obtained. Since 43% ($n=40$) of the articles contained just one visual representation (e.g. a line chart) and 57% ($n=53$) more than one (e.g. a bar chart, a structure diagram and a fact box), individual information visualisations were taken as a unit of analysis. Consequently, the total population of information visualisations analysed was $N=209$ (40 individual visualisations and 169 incorporated into infographics).

A coding sheet with the pertinent research categories was developed using an inductive and deductive integral approach. After a review of the existing literature, a pilot study of a sample of information visualisations ($n=50$) was conducted. This hybrid approach facilitated the definition of two large sets of categories: (1) *basic identification data* (date, newspaper, section, genre and source) and (2) the *individual features of each information visualisation* (syntactic structure of the headline of the graphic, reference in the body of the text to graphic content, representative character of the image, type of visual representation and nature of the technical-biomedical content).

Two independent coders, including the author, coded all of the categories, though the intercoder index was only applied to the non-descriptive ones (second set of categories). A post-graduate assistant was trained as a coder. Regular meetings were held over a period of 3 months to unify criteria and allow the assistant to familiarise herself with the code book and the research objectives and questions. Krippendorff's alpha, a widely employed index in communication research

(Krippendorff, 2011), was used to determine intercoder reliability. On the whole, a coefficient of $\alpha \geqslant 0.80$ was considered reliable, whereas coefficients of $0.80 > \alpha \geqslant 0.67$ indicated that the conclusions should be regarded as tentative (Krippendorff, 2013). The following alpha values were obtained: syntactic structure of the headline ($\alpha = 0.87$), textual reference to graphic content ($\alpha = 0.74$), reference to the representative character of the image ($\alpha = 1$), type of visual representation ($\alpha = 0.83$) and nature of the technical-biomedical content ($\alpha = 1$).

5. Results and discussion

RQ1. It was observed that 87.8% ($N = 209$) of the total number of Ebola-related information visualisations registered during the study period corresponded to those with technical-biomedical content (basically, epidemiological data, viral life cycle, pernicious effects of the infection, or control measures for treating patients to minimise the risk of infection). The other 12.2% (not considered in this study) concerned non-medical information on the Spanish patients (especially Miguel Pajares and Teresa Romero) and the epidemic's collateral aspects (e.g. locator maps of a purely illustrative nature, graphics showing diverse social parameters of the African countries affected, versus the same parameters for Spain, or graphics establishing a parallel between EVD and the fall in the stock market of several companies in the air transport sector).

Other studies have obtained similar results. In her analysis of infographics relating to epidemic risks, Shin (2016) compared the main sources that produced them with their communication goals. She observed that, in media infographics, nearly 85% of the messages were of an informative nature, namely, they displayed technical-biomedical information about the disease. On the contrary, in the infographics of health organisations, informative messages only accounted for 46% of the total.

RQ2. Most of the content was published in August and October 2014 (34.7% and 35.8%, respectively), coinciding with the repatriation of the Spanish missionary Miguel Pajares from Liberia (6 August) and the assistant nurse Teresa Romero's infection in Madrid (6 October) (see Figure 1).

Eight technical-biomedical aspects were identified in the media coverage of this issue: 'epidemiological data' (56%), 'prevention and control measures' (16.3%), 'injurious effects' (12.4%),

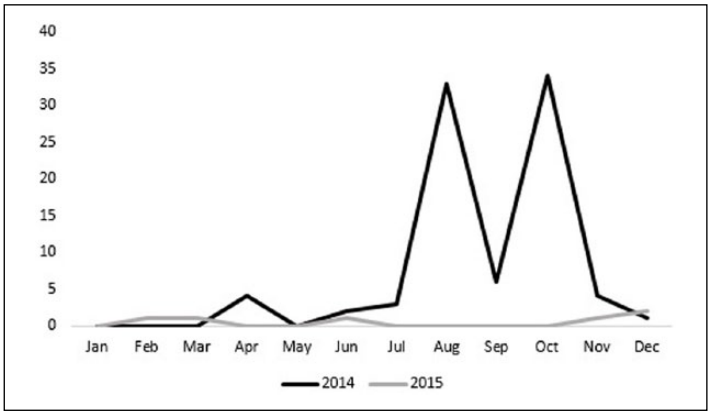

Figure 1. Distribution of frequencies of articles with information visualisations during the epidemic. The sole article published in 2016 (January) is not shown.

Table 1. Distribution of frequencies of the three information scenarios used to contextualise epidemiological data.

	Frequency	Percentage
Scenario 1	91	77.8
Scenario 2	22	18.8
Scenario 3	4	3.4
Total	117	100.0

'therapies and treatments' (6.7%), 'causes of infection' (3.8%), 'viral life cycle' (3.3%), 'viral load in body fluids' (1%) and 'molecular structure of the virus' (0.5%).

The first ('epidemiological data') refers basically to the distribution of the geographical areas of West Africa affected by the disease; the time evolution of the number of people infected, deceased or cured; and mortality rates. During a public health crisis, covering epidemiological information as it is produced is a priority for the mass media, hence its high frequency here. This epidemiological information was published in all of the months preceding and following the peaks occurring in August and October 2014 (69% of information visualisations), which indicates that it was a recurrent and continual phenomenon throughout the media coverage of the issue. In April 2014, several days after the official announcement of the epidemic outbreak, the media began to publish epidemiological data in qualitative map format (reliable numerical data were still unavailable). It was not until June that quantitative data of an epidemiological nature were first published.

Table 1 shows the three scenarios that the written press created to contextualise the epidemiological information. Scenario 1 was the most frequent (77.8%) and pertained exclusively to information on the ongoing Ebola epidemic, Scenario 2 compared data on the current epidemic with those of other previous Ebola outbreaks (18.8%) and Scenario 3 compared data on the ongoing Ebola epidemic with those pertaining to different viral epidemics occurring beforehand (e.g. SARS, bird flu, Middle East Respiratory Syndrome [MERS]) (3.4%).

From the data shown in Figure 2, several interesting conclusions can be drawn about the distribution of technical-biomedical content by newspaper. *ABC* (a conservative, monarchical and Catholic daily) and *El Periódico* (a progressive Catalan newspaper) were those that gave most coverage to this kind of content (25.4% and 24.9%, respectively); the newspaper that paid the least attention to technical-biomedical content was *La Vanguardia*, a centre-right Catalan daily with a national circulation (13.9%), followed by the liberal newspaper *El Mundo* (16.7%). However, *El País* (19.1%), a progressive daily with the largest circulation in Spain, was the newspaper that offered a greater diversity of technical-biomedical content; in effect, it was the daily that provided information on the molecular structure of the virus and the target cells that it infects (endothelial cells and hepatocytes, among others) (*El País*, 7 October 2014) and a unique diagram of the process which showed the windows of time during which the viral load (quantity of the virus) is positive in different corporal fluids (e.g. blood, faeces, saliva, semen) (*El País*, 12 October 2014, reused in another article published on 7 November 2014).[1]

Likewise, it is noteworthy that the two Catalan newspapers (*La Vanguardia* and *El Periódico*) paid less attention to information on control and prevention measures (23.5%) than the dailies published in Madrid, namely, *ABC, El País* and *El Mundo* (76.5%). A plausible explanation for this could be that the Madrid newspapers paid greater attention to the technical aspects of safety (how to put on and take off protective suits and the action protocols keyed to minimising the risk of health workers contracting the disease) to calm public opinion, since the infected missionaries repatriated from Africa were admitted to Carlos III Hospital, Madrid, where the assistant nurse was

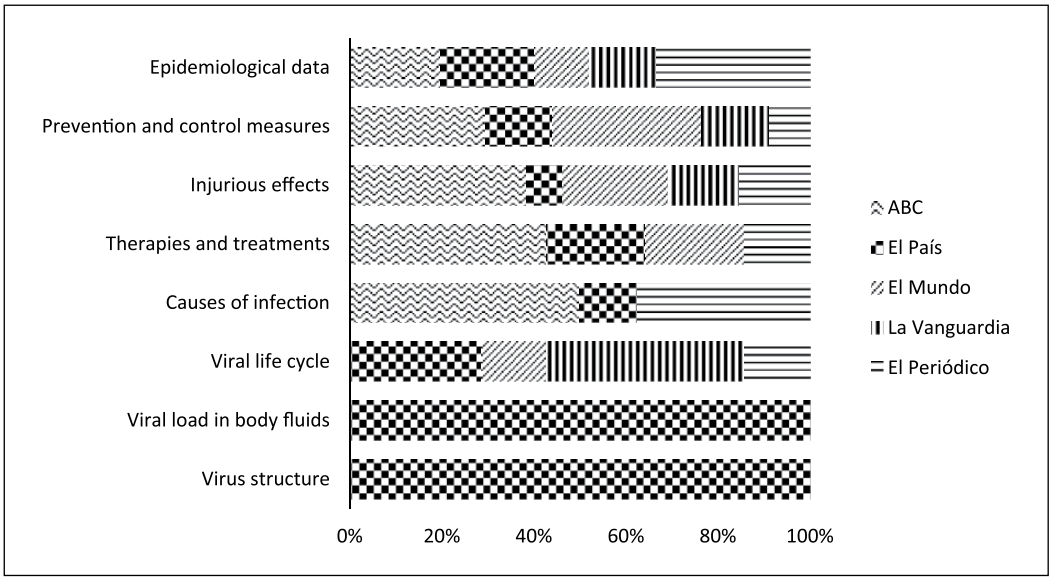

Figure 2. Distribution of technical-biomedical content by newspaper.

also infected. Nonetheless, linked to the journalistic rule of geographical proximity, the influence of popular culture on news coverage should not be overlooked, inasmuch as both the safety measures and the protective gear are easily associated with stereotypes belonging to the realm of science fiction and, therefore, attractive topics for the media.[2]

In order to answer RQ3, the possible association between the nominal variables of 'visual representation' (qualitative, quantitative, mixed and hybrid) and 'technical-biomedical content' was studied by applying the chi-square test. The alternative hypothesis (the existence of association) was substantiated, $\chi^2(21, N=209)=121.88$, $p<0.001$.

The close relationship between the content and its forms of representation is described below. All the quantitative graphics and quantitative maps ($n=66$) were used exclusively to represent epidemiological data (see Table 2). This result is consistent with the fact that people tend to place more trust in numerical information on health- and risk-related issues than in other formats, but usually have difficulty in understanding it (Bell et al., 2006). Visual aids allow for a better and easier interpretation of quantitative information (see, for example, Stone et al., 2015; Tufte, 1983). The findings here concur with the results obtained by other authors (DiFrancesco and Young, 2010; Rebich-Hespanha et al., 2015; Smith and Joffe, 2009). For instance, to represent statistic data on climate change (e.g. the volume of greenhouse effect gases emitted by country or temporary changes in atmospheric CO_2 levels), the British press relied on a large number of bar charts and line graphs (Smith and Joffe, 2009).

For Welhausen (2015), the use of maps and line charts highlighted the sensation of risk during the last EVD epidemic: the former because they transcended national and international borders, and the latter due to the fact that they showed a continuous increase in the number of people infected by the virus and the rising death toll in West Africa. In the Spanish case, this feeling was even more pronounced, since the first case of infection in Europe occurred in Madrid on 6 October 2014.

Likewise, the qualitative maps (chorochromatic, $n=21$, and explanatory, $n=1$), flowcharts (qualitative, $n=3$), locator maps (qualitative, $n=5$, and quantitative, $n=9$) and hybrid maps

Table 2. Types of quantitative graphics and quantitative maps used to represent epidemiological data.

Type of graphic	Frequency	Percentage
Line chart	15	22.7
Bar chart	12	18.2
Bubble chart	10	15.2
Area chart	8	12.1
Numerical data table	5	7.5
Proportional symbol map	10	15.2
Choropleth map	6	9.1
Total	66	100.0

(chorochromatic-proportional symbol, $n=5$, and chorochromatic-dot, $n=2$) registered were also used merely for visualising 'epidemiological data'. This technical-biomedical information was also represented by timelines ($n=7$), fact boxes ($n=1$) and illustrations ($n=1$).

'Prevention and control measures' appeared in practically any qualitative format ($n=34$), except timelines. These featured above all structure diagrams ($n=12$), thanks to which the elements and primary functions of the protective suits worn by health workers in contact with patients were described. Process diagrams ($n=7$) and floor plans ($n=6$) were relevant as well. The former were basically diagrams with illustrations of health workers in the process of putting on or taking off their protective suits, while the latter were diagrams of the floor of Carlos III Hospital, Madrid, where the Ebola patients were isolated. The floor plans contained additional written information to describe the different elements of rooms (e.g. 'class II biosafety laboratory', 'closed-circuit ventilation system', 'medical hazardous waste container') and the actions performed by health workers (e.g. 'health workers should wash their hands before entering and leaving').[3]

'Injurious effects' were generally represented by process diagrams ($n=23$), with two different designs that, nevertheless, had the same function: (1) diagrams in which human pictograms were used (indicating the damaged areas) and, sometimes, arrows (indicating the direction of temporal movement),[4] and (2) the graphic designers found an ingenious solution for saving space and visually engaging readers in the use of a transparent plan of the human body and different colours to represent the anatomical areas affected and their associated symptoms (with written text), depending on the stage of the disease (see Figure 3).

To represent 'therapies and treatments', fact boxes ($n=8$) were used above all: this is an ideal tool for synthesising, in an orderly way, the different preventive strategies, therapies and treatments. By the same token, suitable process diagrams ($n=4$) were employed to describe the sequential stages in the process of obtaining effective drugs, as well as timelines ($n=2$).

'Causes of infection' were only represented by text-based graphics (fact boxes, $n=4$, and schemata, $n=3$), which allowed for the organisation and hierarchisation of the different aetiological aspects of EVD.

'Viral life cycle' was only displayed with process diagrams ($n=7$), the best way of representing this attractively with illustrations, pictograms and arrows indicating the direction of movement.

Lastly, the two cases of 'viral load in body fluids' were represented with process diagrams, and the sole example of 'virus structure', by a structure diagram (see explanation above).

Answering RQ4 is no easy matter. In infographics, it is not always possible to relate a specific visualisation to a particular source, since its source lines usually include multiple sources. However, several thought-provoking conclusions can be drawn from the data.

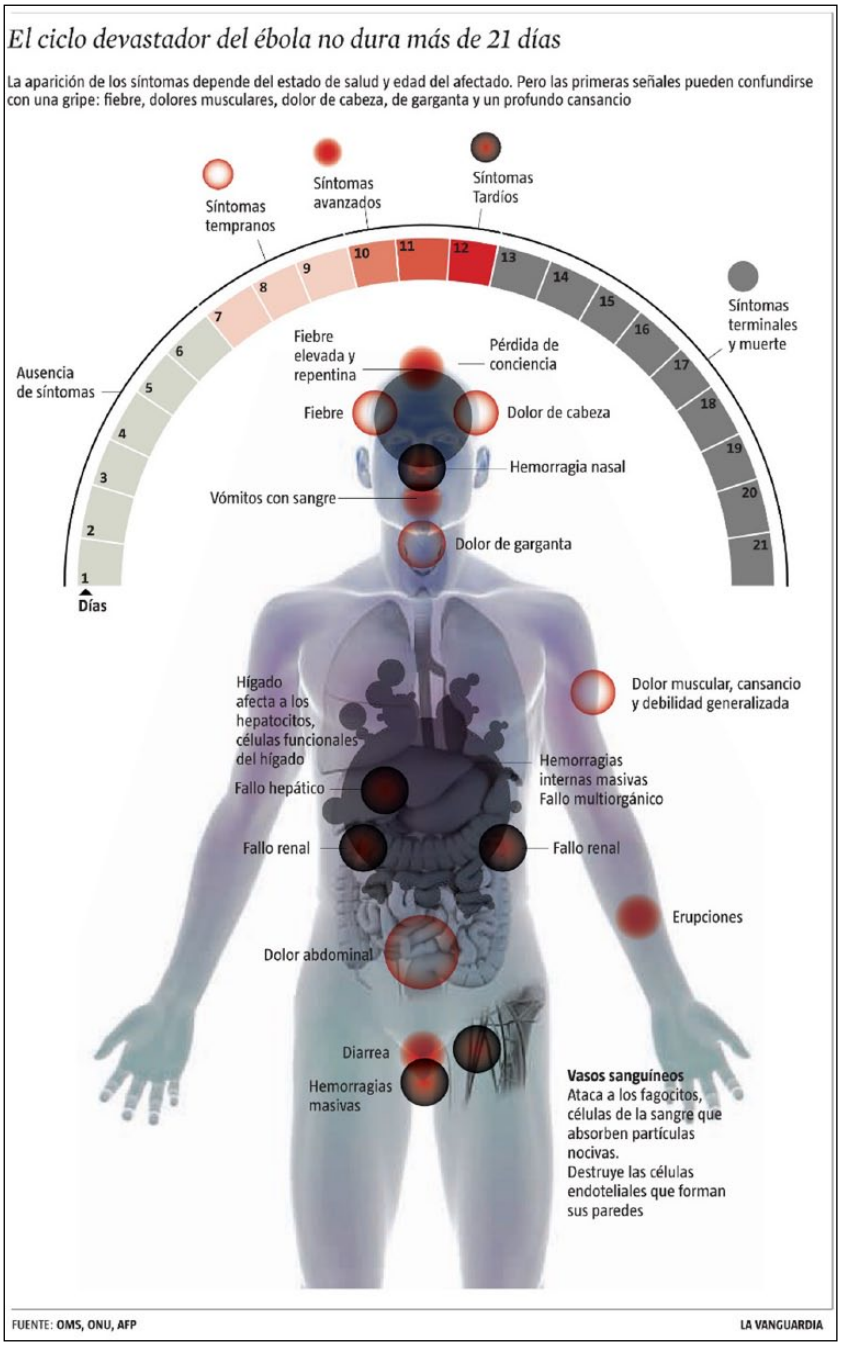

Figure 3. Process diagram representing the symptoms associated with the different stages of infection.
Source: reproduced with permission from *La Vanguardia*, 2016, *La Vanguardia*, 11 October 2014.

The WHO was the most frequently cited information source (71.8%). On the whole, expert sources (institutions or research centres like the WHO or the Centre for Disease Control and

Prevention (CDC), or specialised journals such as *Science* or *The New England Journal of Medicine*) were the most regularly cited (49.2% as a sole source; 79.4% in conjunction with other types of sources, such as media companies or press agencies). These findings suggest that expert sources played an exceedingly relevant role in the production of information visualisations. Whereas the public discourse on the government's handling of the crisis and its damaging effects on the economy involved contradictory postures, acrimonious debates and bitter controversies, the visual discourse of the technical-biomedical aspects was constructed apodictically on the basis of supposedly sound information supplied by sources with cognitive authority and social legitimisation.

In order to answer RQ5, it was understood that there was a textual reference to graphic content only if there was a certain (partial or complete) discursive development of the content of the visualisation in the body of the text. The chi-square test was employed for the individual visualisations and those included in infographics, alike. The analysis produced a p value $= 5.78\ 10^{-9} < .001$ (significance level of 99%), $\chi^2(2, N = 209) = 35.97$, $p < .001$. This result suggests that there was indeed an association between the visualisations and the journalistic texts in which they were inserted. A more in-depth analysis revealed that this association was highly dependent on the individual or integrated character of the information visualisations. The individual ones did not appear to function independently of the text in which they were inserted and, therefore, comprehension depended on the written information that the article in question provided. Nonetheless, the visualisations incorporated into infographics were interconnected by thematic juxtaposition to narrate a complex story. Thus, it could be said that the infographics were capable of functioning independently, behaving as a unit of meaning.

RQ6 examined whether or not there was any reference to the representative character of the image in the written text or the information visualisation itself. There was no such reference in any of the cases. This finding is consistent with studies such as those of Myers (1990) who underscores the fact that scientific discourses are based on two opposing visions. On the one hand, professional discourse ('research articles') constitutes a narrative of science that sustains and emphasises the arguments of the scientist and the conceptual structure of the discipline. On the other hand, public discourse ('science popularisation') represents a *narrative of nature* in which entities and natural phenomena – instead of scientific practices – are the focal point. By presenting scientific facts as irrefutable and conclusive, science popularisation contributes decisively to naturalising the representation itself, charging its scientific referent with ontology (Roqueplo, 1983). Indeed, by 'charging itself with ontology' science popularisation discourse generates the sensation that scientific facts speak for themselves and are thus self-evident. In this way, popularisation contributes to minimising, when not concealing, the role of the person who makes or interprets a scientific discovery.

The lack of references to the representative nature of the information visualisations reinforced the narrative of nature model that Myers (1990) observes in products keyed to science popularisation. Information visualisation would then be a direct tool at the service of journalists to narrate the unquestionable reality of the Ebola epidemic, rather than a graphic resource that contributed to the social construction of the outbreak.

RQ7: Nominalisations had the greatest frequency of occurrence (88%; e.g. 'Advance of Ebola in Africa'). Lagging far behind these were declarative sentences (4.8%; e.g. 'All of the outbreaks have occurred in Equatorial Africa'), demonstrative sentences with the adverb 'like' (1%; e.g. 'This is what the drug against Ebola is like'), interrogative sentences (1%), indirect interrogative sentences with 'what … like' (1%; e.g. 'What protective gear against biological and chemical agents should look like') and sentences expressing probability with a conditional verb (0.5%; e.g. 'Ebola might have already been responsible for 70 deaths in Guinea'). In all, 3.8% of the visualisations did not have headlines.

The nominal sentence is a rhetorical device with 'important ideological functions such as deleting agency and reifying processes' (Billig, 2008). By concealing the subject, lending inexpressiveness to the sentence and reifying the referents, the nominal style highlights the facts and gives them a patina of 'objectivity'.

In this analysis, it must also be stressed that demonstrative sentences with the adverb 'like' were used to headline information on 'therapies and treatments'. Specifically, *ABC* used the same diagram at different times to describe the manufacturing process of drugs for combating the action of the virus ('This is what the drug against Ebola is like', 11 August 2014, and 'The drugs against Ebola are manufactured like this', 13 August 2014). The diagram displayed a logical sequence of steps taken by researchers to obtain the end product (the drug). Each step in the chain of actions was numbered and included an explainer (an additional text that started with an impersonal passive sentence using 'it' in the present tense). The impersonal passive voice with which these steps were related allowed the journalist in question to focus the narrative more on natural entities (mice, monoclonal antibodies, viruses, tobacco plants and patients), than on the procedural and experimental decisions that were being adopted by researchers in an attempt to obtain a viable and effective drug.[5]

6. Conclusion and key findings

Given the lack of existing literature on the subject, this study could contribute to a better understanding of the role that information visualisation plays in the popularisation of scientific content in general, and the technical-biomedical aspects of EVD in particular. Based on a relevant theoretical frame, a content analysis was performed to explore issues relating to the content, structure and function of information visualisations in the Spanish written press.

The results suggest that visual representations were very important for popularising technical-biomedical content of a certain complexity to wide audiences. They also seem to imply that, firstly, there was a significant association between the content and its graphic formats of representation. Secondly, the most relevant information sources were expert ones (above all health organisations and research centres), which enjoy a greater level of cognitive authority and social legitimacy. Thirdly, that the understanding of individual representations (nearly always data visualisations) depended to a certain extent on the written text in which they were inserted. On the contrary, there is evidence that the information visualisations incorporated into infographics helped to convert these into units of meaning that functioned independently of the text in which they were inserted. Fourthly, the absence of any written indication of the representative character of the graphics appears to indicate that the representation was really regarded as the object, rather than its discursive construction. And lastly, in consonance with the previous finding, the analysis of the syntactic structure of the headlines of the graphics revealed the predominance of sentences that tended to suppress the subject and create an impression of objectivity.

These last two findings appear to suggest that the information visualisations followed the narrative of nature model that Myers (1990) observed in products destined for science popularisation. Nearly 90% of the visual representations published during the study period popularised technical-biomedical content of some complexity. Thus, the epidemiological information and the damaging effects provoked by the virus in humans in each stage of the infection cycle were the predominant topics, a finding consistent with the basic feature of all epidemics: their dynamics.

It has been suggested that information visualisation is one of the most efficient tools for displaying large epidemiological/statistical datasets, since the public apparently tends to place greater trust in numerical information than in other types of data (e.g. Bell et al., 2006; Stone et al., 2015). This study has shown that all the quantitative graphics and maps were used by the journalists to

represent epidemiological data alone. Moreover, it was observed that each newspaper employed its own graphic design templates (primarily, line and bar charts) which were periodically updated with new epidemiological information provided by expert sources. It has been established that the type of graphic format influences risk perception (Schapira et al., 2006) and that bar and line charts are ideal for making comparisons and showing trends over time, respectively (Lipkus, 2007).

As noted by Jordan et al. (2009), 'content analysis research is limited in terms of what content patterns can tell us about effects of health messages on the audience'. Therefore, the need arises to develop future lines of research in order to explore how visual representations affect public awareness and understanding of science. Empirical studies of science literacy have neglected, to a great extent, the visual aspect of the public communication of science. In an attempt to tackle this problem, Bucchi and Saracino (2016) have performed perception analyses based on different 'empirical indicators of visual science literacy' (p. 812). The preliminary results seem to indicate that the respondents are more familiar with visual than written information on science, which suggests that images can be an efficient way of engaging the public with scientific research results. Accordingly, information visualisations could be an effective tool for facilitating technical-scientific knowledge and encouraging certain prophylactic behaviours (Occa and Suggs, 2016).

Additional work may be required to explore the reactions of readers to online information with or without graphic representations. The interactivity of online formats allows us to gain insights into these reactions and to ascertain to what extent information visualisations can influence public understanding of technical-scientific content.

Likewise, it would be interesting to perform a comparative analysis of graphic representations and their communication purposes (e.g. to inform, persuade, appeal to) in both Western media and those of the African countries affected by EVD.

Lastly, a key ethical implication can be derived from this study: graphic journalists who work with information that is sensitive for the public should strike, as recommended by Cairo (2013), a balance between rigorous reporting and an aesthetic format.

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Notes

1. These graphics can be consulted at: http://elpais.com/elpais/2014/08/09/media/1407595020_722065.html and http://elpais.com/elpais/2014/08/11/media/1407779252_015727.html
2. A number of significant examples can be seen in the following links of the digital versions of *ABC, El País* and *El Mundo*, respectively: http://www.abc.es/sociedad/20141016/abci-ebola-trajes-ventilacion-carlosiii-201410152044.html; http://elpais.com/elpais/2014/10/08/media/1412795366_182631.html; http://hemeroteca.lavanguardia.com/preview/2014/10/12/pagina-44/94534796/pdf.html
3. For illustrative examples, see: http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/2014/10/16/040.html; http://elpais.com/elpais/2014/10/08/media/1412795366_182631.html; http://www.elmundo.es/salud/2014/10/09/5435a1ea22601d9b468b4592.html
4. For illustrative examples, see: http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/2014/10/10/018.html; http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/2014/10/10/019.html
5. See example at: http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/2014/08/11/029.html

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