THE ESTIMATION OF HEALTH-RELATED QUALITY OF LIFE LOSSES DUE TO A TECHNOLOGICAL DISASTER IN BRAZIL USING THE EQ-5D-3L

Monica Viegas Andrade, PhD[1]; Kenya Valéria Micaela de Souza Noronha, PhD[1]; André Soares Santos, PhD[1,3]; Aline de Souza, BEc[1]; Gilvan Ramalho Guedes, PhD[2]; Bernardo Campolina, PhD[1]; Anderson Cavalcanti, PhD[1]; Aline Souza Magalhães, PhD[1]; Denise Duarte[4], PhD; Paul Kind, PhD[1].

[1]Center for Development and Regional Planning (CEDEPLAR) – Department of Economics– Universidade Federal de Minas Gerais – Av. PresidenteAntônio Carlos, 6627 – Pampulha – CEP 31.270-901 – Belo Horizonte, Brazil.
[2]Center for Development and Regional Planning (CEDEPLAR) – Demography Department – Universidade Federal de Minas Gerais – Av. PresidenteAntônio Carlos, 6627 – Pampulha – CEP 31.270-901 – Belo Horizonte, Brazil.
[3]Center for Health Technology Assessment of the UFMG Teaching Hospital (NATS-HC/UFMG)– Universidade Federal de Minas Gerais – Av. Alfredo Balena, 110 – Santa Efigênia – CEP 30.130-100 – Belo Horizonte, Brazil.
[4]Statistics Department – Universidade Federal de Minas Gerais – Av. PresidenteAntônio Carlos, 6627 – Pampulha – CEP 31.270-901 – Belo Horizonte, Brazil.

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Funding: This study was financed by Caritas-Regional Office of Minas Gerais to estimate the compensation payments for the victims of the Samarco Dam Failure in Mariana, Brazil.

Corresponding author:
Mônica Viegas Andrade
E-mail: mviegas@cedeplar.ufmg.br
Centro de Desenvolvimento e Planejamento Regional (CEDEPLAR) – Faculdade de Ciências Econômicas - Departamentode Economia– Sala3048 – Universidade Federal de Minas Gerais – Av. Presidente Antônio Carlos, 6627 – Pampulha – CEP 31.270-901 – Belo Horizonte, Brasil.

ABSTRACT

OBJECTIVE: This study aims to use EQ-5D-3L to estimate HRQoL loss due to one of the largest technological disasters in the world. **METHODS**: We collected data from a probabilistic sample of 459 individuals aged over 15 years old. Pre-event data were not available for this population so that respondents were asked to currently and retrospectively evaluate their health status using EQ-5D-3L. As far is known, this is the first application of EQ-5D in measuring a negative health shock suffered by an entire community. **RESULTS**: Catastrophic losses due to the Samarco disaster were found. Around 72% of the study population suffered some HRQoL loss. On average, EQ-5Dindex values decreased from 0.94 to 0.74 , resulting in a mean loss of about 29% for men and 32% for women. **CONCLUSION**: The EQ-5D-3L instrument showed feasibility and sensitiveness to measure HRQoL losses due to a negative health shock in a low-income Brazilian population.

1 INTRODUCTION

In November 2015, the municipality of Mariana, in Brazil, staged one of the largest technological disasters in the world [1]. After the dam collapse at the Samarcoiron ore mine (a joint venture between Vale S. A. and BHP Billiton Ltd.), more than 600 km of watercourses were contaminated, and almost 1,600 ha of vegetation was destroyed. The path traveled by the mud swept the districts of Bento Rodrigues, Paracatu de Baixo, and Gesteira, and left several communities temporarily without adequate water supply and permanently affected agricultural, fishing and commercial activities. A total of 229 municipalities and 3.3 million individuals were somehow impacted by the disaster. In Mariana alone, nineteen people died, one miscarriage was reported, one individual disappeared, and around 900 families had their lives affected [2,3].

Empirical studies have already shown the more intense and pervasive impact of technological disasters on individuals' wellbeing when compared to natural disasters[4,5]. They differ in terms of etiology, social, environmental, and health impacts, as well as in how communities react. While natural disasters are usually perceived as inevitable or "acts of God", technological disasters are associated with

human failure and, in this sense, the affected in particular and the society *wit large* are more likely to identify the responsible parties [5,6]. Even when the parties are recognized, the lack of consensus around the identification of the damages caused by a technological disaster can make it difficult to assign liabilities and to repair the victims. As a result, it is not possible to have the well-defined linear chronological structure (preparation, answer, recovery, and mitigation) usually observed in natural disasters. Instead, a cycle of guilt, social unrest,and revolt is often observed, which contributes to enhancing the impact on health-related quality of life (HRQoL)[4,5,7–9].

Three main groups of risk factors are usually associated with an increased likelihood of health disorders due to disasters [10]. The first is related to the extension of the disaster that causes deaths, morbidities, destruction, environmental adversities, and evacuation of communities[11–17]. In Mariana, there is no doubt about the magnitude of the immediate consequences of the dam collapse. Besides the nineteen deaths,a large extension of landwas affected, whole communities were buried and consequently displaced.

The second group of risk factors is associated with post-disaster circumstances that may alleviate or exacerbate the socioeconomic, health, and environmental impacts. The ability of the responsible actors in providing prompt emotional and financial support is crucial for the healing process of the affected communities[9,18–23]. In Mariana, Samarco and the government failed to take immediate action; even the evacuation process was organized bythe communities with little or no institutional help. There was no warning after the dam collapsed and several individuals overnighted in the woods without any assistance. Only in 2016, after most of the damage has occurred, a settlement agreement was signed among Vale, Samarco, BHP and the Brazilian government to develop socioenvironmental and economic mitigation actions against damages. A new governance structure comprised of two legal entities was created: the Renova Foundation and the Interfederative Committee. Renova became responsible for developing and implementing the redress programs.The Interfederative Committee, an independent body, formedmainly by representatives of the federal and state governments, was given authority to monitor the activities of the RenovaFoundation. Under this settlement agreement, Renova is in charge of identifying the affected individuals as well as their damages to organize and provide judicial remedies[24,25]. The process has been bureaucratic and time-consuming, and this arrangement has clear

conflicts of interest since Renovais directly linked to Samarco. Three years after the disaster, the communities still struggle to get financial compensation, including the compensating loss related to the health of their residents.

The third group of health-related risk factors is associated with personal vulnerabilities such as sex, age, and socioeconomic status [11,14,26–28]. Cherry et al. [21] analyzed the impact of disasters on post-traumatic stress disorder (PTSD) among individuals who were differently exposed to the 2005 Hurricanes Katrina and Rita and the 2010 British Petroleum Deepwater Horizon oil spill. Individuals of lower socioeconomic status and those with lower levels of social support were more likely to develop depression and mental health disorders. According to the authors, the coastal fishers, who were unable to work for one year or more due to the consequences of the disaster, were the most vulnerable group in terms of health losses. An analogous context is observedin Mariana, where displaced families lost their subsistence activities such as family farming, fishing, and handicraft business. As income losses caused by the disaster can exacerbate the health damages, the most vulnerable groups will be more likely to experience long-term health consequences [7,8,11,18,26].

Another concern regards stigmatization and prejudice against the victims due to the economic impacts they suffered and, in some cases, the risk of contamination as, for example, in Chernobyl. Technological disasters usually affect global and local economies depending on its extension and the economic importance of the company [7,9]. In the State of Minas Gerais, where Mariana is situated, the mining activities have been largely relevant, responding on average for 4.5% of the total Minas Gerais Gross Domestic Product (GDP) during the 2005-2011 period [29]. Recent data showed that the unemployment rate in Mariana increased by 30% after the disaster [3]. In this context, affected individuals have been blamed for the economic collapse experienced by the municipality after the event [2].

Empirical evidence for health impacts due to technological disasters is mostly associated with the Chernobyl nuclear power explosion in 1986 [15,16,30–34]. For instance, Bromet, Havenaar e Guey[10], in a retrospective review, showed that even after 25 years of the Chernobyl disaster, mental health impacts are still an issue. Some studies evaluating the health impacts for other technological disasters were also found such as Buffalo Creek dam collapse in 1972 [27,28,35,36], British Petroleum Deepwater Horizon oil spill in 2010 [7,8,26], Graniteville train crash in 2005 [37],

andthe Three Mile Island nuclear accident in 1979 [38,39]. According to the empirical evidence, there is a consensus regarding long-term effects of technological disasters mainly on mental health among children and adults victims as well as first responders and clean-up workers [10,12,27,31–34,36,40]. Few studies analyze the HRQoL loss due to technological disasters[21,41,42]. They usedthe SF-36 instrument as a measure of HRQoL and reported important health impacts.

Some short-term health consequences of the Samarco tragedy, including infectious, respiratory, skin, and psychological diseases have already been reported elsewhere [43,44]. In 2017, a high prevalence of depression (28.9%) and PTSD (12%) were observed among affected individuals. The prevalence of depression is five times higher than what is observed in the general population [2]. These results, however, are not an accurate measurement of health loss since they do not control for individual health status before the disaster. Besides, health impacts were evaluated only considering the presence of specific diseases or mental health disorders. Much less is known about the HRQoL losses, which represents more comprehensively individuals' wellbeing. This paper aims to fill this gap by using the EQ-5D-3L instrument to measure the negative health shock suffered by an entire community. The EuroQol instrument has already been used to measure HRQoL losses due to natural disasters. The estimated impacts are significant with short-term and long-term consequences for the survivors[45,46]. According to Khachadourian et al.[46]the estimated long-term HRQoL losses were even worse among individuals who did not receive any financial/material aid. To the best of our knowledge, this is the first application of EQ-5D-3L to measure health losses due to technological disasters.This analysis is important due to the differences between both type of disasters regarding their conception and consequences to the affected individuals.Besides, the estimation of health losses will form the basis for the calculation of compensation payments for the victims.

2 METHODS

2.1 Study Design

Household face-to-face interviews were conducted in December 2018 with the application of the EQ-5D-3L questionnaire [47]. An independent external company was hired to perform the interviews. The application of the instrument was approved by the

EuroQol Group (ID# 27832). To evaluate the loss of health caused by the dam collapse, health status measurements for at least two points in timewere necessary. Pre-event data was not available for this population, so respondents were asked to currently and retrospectively evaluate their health status using EQ-5D-3L. The retrospective questions referred to the year of 2015, representing a point in time before the disaster. They were evaluated after the assessments of current health status to minimize any potential bias related to the induction effect. Individuals may have more incentives to overstate their current adverse health conditions after evaluating pre-event health status as they become more aware of the research purposes. Additionally, because longitudinal data was measured using retrospective questions, selectivity due to sample attrition is probably less important.

The EQ-5D-3L questionnaire is composed by the five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with three levels of severity (no problems, moderate problems, and severe problems) and a visual analog scale (VAS) [47]. After answering the EQ-5D instrument, information about age, sex, and self-reported health status composed of five levels (very good, good, regular, bad, or very bad) were collected.

2.2 Sample

The size of the affected population was obtained from a general registry database (GRD) used by stakeholders to identify the affected families for social support and compensation purposes. A sample of 459 adult individuals from a total of 2,452in the GRD was estimated from a multinomial probability distribution with 5% precision error for the estimated proportions and a 5% significance level for the confidence interval[48]. The probabilistic sample encompassed individuals at least 15 years old and was stratified by sex and age groups (15 to 49 years old, 50 to 69, and 70 or more). The replacement was accepted after two frustrating attempts to reach the selected subjects.

All respondents filled consent forms to participate in the research. The Research Ethics Committeeof the Federal University of Minas Geraisapproved this research(CAAE#10975718400005149).

2.3 Data Analysis

The main challenge to estimate the HRQoL is the absence of pre-event health status. To address this issue, we proposed two potential pre-event sources for the EQ-5D estimates. The first one was based on theinformation of individuals health status takenfrom a representative sample of the State of Minas Gerais(MG) that comprises 3,362 individuals aged between 18 and 64 years old [49]. Ideally, we should match individuals one-to-one from MG to Mariana sample using observable characteristics. Since the sample size is too different between the two distributions, it was not possible to conduct one-to-one pairing. To improve the comparability between these two samples, we used the only two observable characteristics (age and sex) available in both datasets to conduct a direct standardization:5-year age and sex groups were considered.That is, the distribution of EQ-5D health states (h) for the MG populationwas standardized by the age (a) and sex (s) distribution of the Mariana sample(MA) as described in equation (1).

$$prop_{h,a,s}^{MG} = \sum_{a,s} \frac{pop_{h,a,s}^{MG}}{pop_{a,s}^{MG}} x \frac{pop_{a,s}^{MA}}{pop^{MA}} \quad (1)$$

As the age range is larger in Mariana distribution, we restricted this sample only to individuals aged between 18 and 64 years old.

The second potential pre-event was based on the retrospective EQ-5D questions. The HRQoL losses were estimated by comparing the health utilities ($EQ\text{-}5D_{index}$ values) of the Mariana sample before and after the disaster using the two potential pre-event EQ-5D health status. The MG societal value sets for ED-5D-3L health preferences estimated by Andrade *et al.* (2013) were used to determine the utility associated with the respondents'health status. Utility changes were calculated for the whole sample and for a subsample of individuals who experienced health losses.

Differences between groups were evaluated by the Pearson χ^2-test for categorical variables and by the Kruskal-Wallis test for continuous variables. A Kolmogorov-Smirnov test for stochastic dominance was applied for the utility distribution before and after the disaster. For hypothesis testing, p-values lower than 0.05 were considered statistically significant.

3 RESULTS

3.1 EQ-5D-3L health status distribution before the dam collapse

Table 1 compares the characteristics distribution of the sampled individuals to the GRD that encompasses the entire affected population. No significant differences were foundin terms of age, sex, education status, as expected.The affected population is mostly female and aged between 15 and 49 years old. Education distribution is bimodal, presenting almost 40% of individuals with less than middle school and only 31% with complete high school. This education distribution reflects the high level of education dropout usually observed in Brazil.

Table 1. General characteristics of sampled individuals compared to the General Registry population (aged over 14 years old).

Variable	Sample	General registry	P-value
Age	Mean=41.9 (SD=17.6)	Mean=41.0 (SD=17.5)	0.09
15-49	66.7 (n=306)	70 (N=1653)	
50-59	15.9 (n=73)	14.5 (N=342)	0.222
60+	17.43 (n=80)	15.5 (N=365)	
Sex (%)			
Female	51.6 (n=237)	49.7 (n=1194)	0.366
Male	48.4 (n=222)	50.3 (n=1208)	
Education (%)			
Did not attend school	4.4 (n=20)	5.8 (n=136)	
Less than middle school	39.6 (n=180)	36.3 (n=850)	
Complete middle school	19.1 (n=87)	18.8 (n=440)	0.204
Complete high school	31.0 (n=141)	31.5 (n=738)	
Complete undergrad or more	5.9 (N=27)	7.5 (N=180)	

Table 2 reports pre-event EQ-5D health status for the two potential measures. The first is the retrospective self-reported EQ-5D health status for Mariana sample, and the second is the standardized EQ-5D health status distribution for MG.

Table 2. Proportion of individuals in each dimension and level of the EQ-5D-3L scale of the affected individuals before the dam collapse compared to the standardized distribution for Minas Gerais and their EQ-VAS and EQ-5D mean utility scores.

		Levels of severity		
EQ-5D Dimension	**Samples**	**No problems**	**Some problems**	**Extreme problems**
Mobility	MG*	90.84	9.06	0.1
	Mariana	91.5	7.9	0.7
Self-care	MG*	97.6	2.06	0.34
	Mariana	98.7	1.4	0.0
Usual activities	MG*	90.15	9.4	0.45
	Mariana	96.0	4.0	0.0
Pain/discomfort	MG*	57.13	38.93	3.94
	Mariana	77.7	22.1	0.3
Anxiety/depression	MG*	64.07	31.64	4.29
	Mariana	86.9	12.3	0.9
Scale	**Samples**	**Mean scores**		
EQ-VAS	MG*	$\bar{x}$=83.0		
	Mariana	$\bar{x}$=90.8		
EQ-5D Utility	MG*	$\bar{x}$=0.885		
	Mariana	$\bar{x}$=0.952		

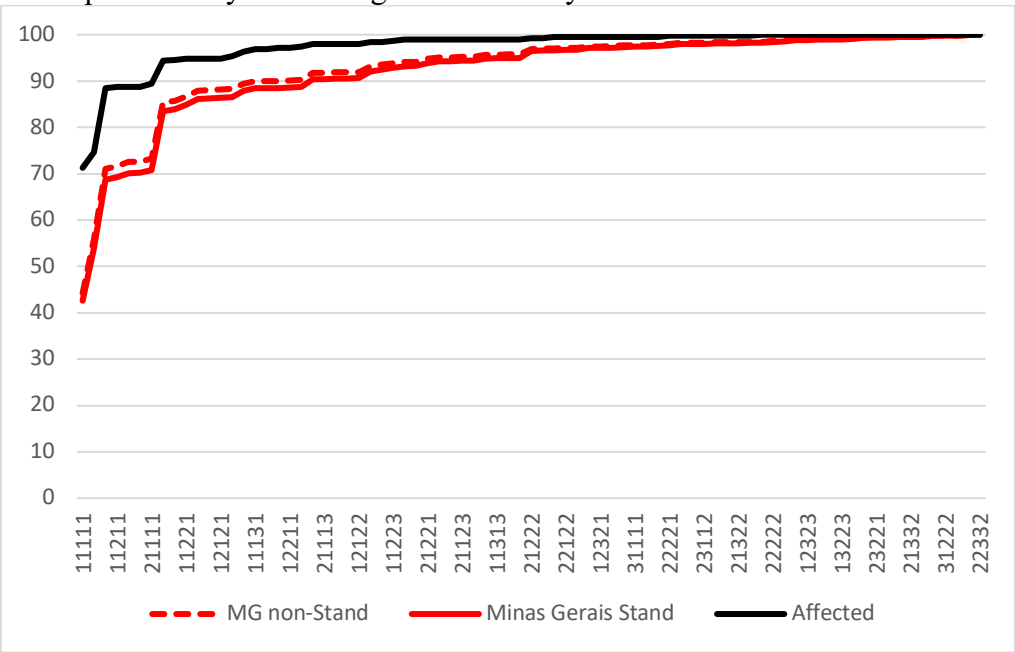
*MG data was standardized by the age and sex distribution of the population of Mariana;$\bar{x}$=mean.
MG $EQ_{5D\ value\ set}$was used to estimate utilities for both samples. Mariana sample was restricted to individuals between 18-64 years old.

Compared to the standardizedMG population, affected individuals reported better health conditions before the dam collapse. Differences are larger for the pain/discomfort and

the anxiety/depression dimensions. InMariana, 77.7% and 86.9% of individuals, reported not having problems in these dimensions, respectively,compared to57.13% and 64.07% for the MG standardized population. In Minas Gerais, a relatively high number of individuals had moderate problems compared to the inferred rate for individuals in Mariana before the disaster(38.93% and 31.64% compared to 22.1% and 12.3%**Table 2**). For the other EQ-5D dimensions, the distributions in both samples are similar.In Mariana, 91.5%, 98.7%, and 96.0% reported no problems with mobility, self-care, and usual activities before the dam collapse, while the figures for MG were 90.84%, 97.6%, and 90.15%. The average EQ-5Dand EQ-VAS utility for the Mariana respondents wererespectively 7.5% and 9.4% higher than that of the standardized Minas Gerais sample (0.952 *vs.* 0.885 for EQ-5D and 90.8 *vs.* 83.0 for EQ-VAS).

Figure 1 shows the cumulative distribution of the individuals' health states in decreasing order of utility for both samples. For MG sample, we plot two curves, standardized and non-standardized, which are very similar.The Marianacurve is above both curves for the MG sample. The area between Mariana and MG curves shows that the largest differences between these distributions occur for moderate health states. For instance, the proportion of affected individuals aged between 18-64 years old with full health before the event reaches 71.3%, against 42.6% in the standardized Minas Geraissample.

Figure 1. Cumulative distribution of EQ-5D-3L health states of the affected individuals before the dam collapse compared to the standardized and non-standardized Minas Gerais samplesorted by decreasing order of utility.



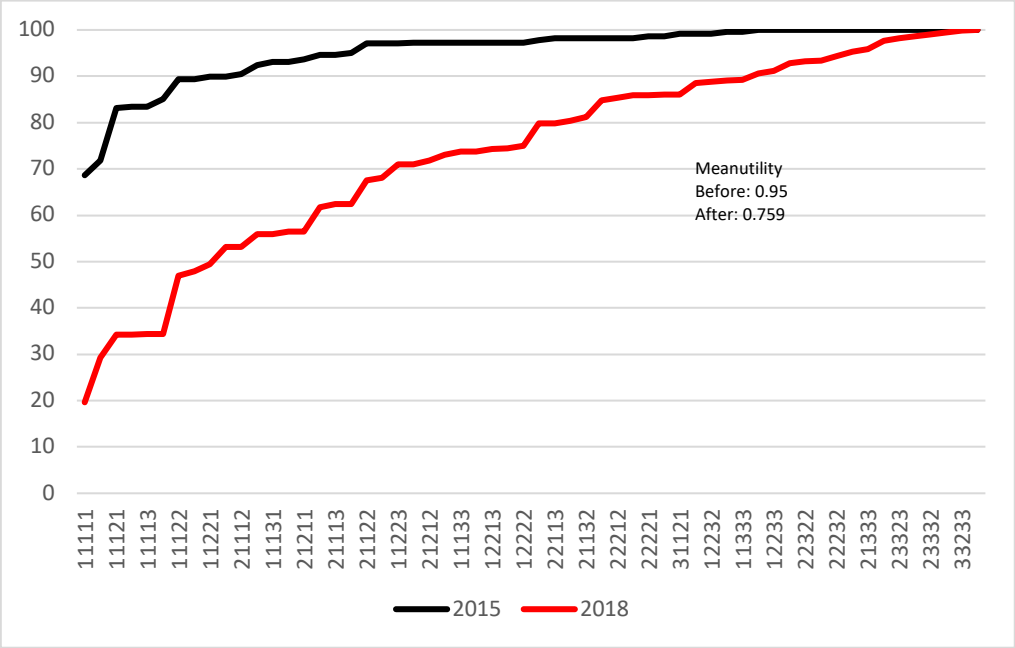
Note: The utility EQ-5D health index was extracted from Andrade et al. (2013).

3.2 HRQoL losses estimation

We estimated HRQoL due to the Samarco disaster using the two potential measures for pre-event. First, the retrospective EQ-5D-3L scores reported for 2015by Mariana sample were compared to the current scores. For this estimation, all age groups in the Mariana sample were considered.

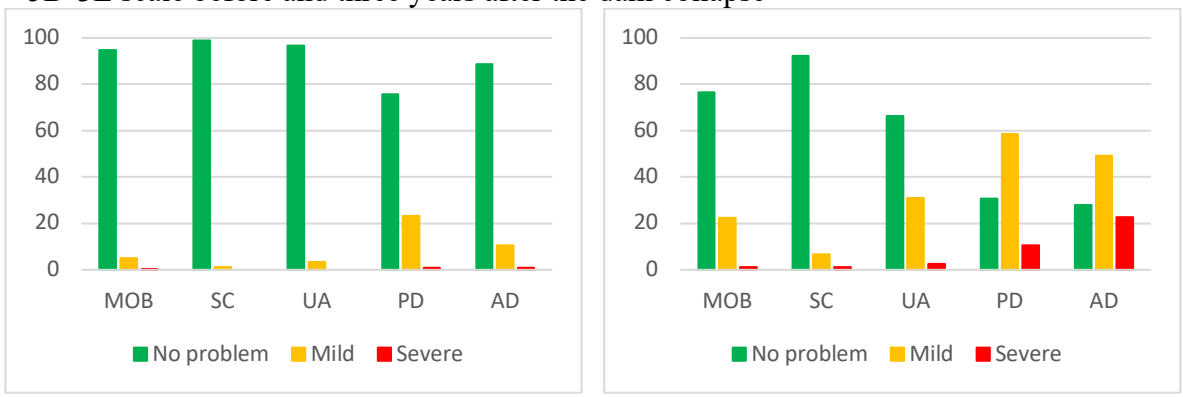
Catastrophic losses due to the Samarco disaster were found with around 73.64% of the adult population suffering some HRQoL loss. **Figure 2** shows the cumulative distribution of the individuals' health states from Mariana before and after the disaster in decreasing order of utility. The curve associated with the pre-event utility is above its analog after the event(p-value<0.001). Before the tragedy, 69.9% of the sample reported full health compared to only 16.2% in 2018 (p-value<0.001). On average, EQ-5D$_{index}$ values for the adult population decreased from 0.947 to 0.759 (p-value<0.001).

Figure 2. Cumulative distribution of EQ-5D-3L health states of the affected individuals before and three years after the dam collapse sorted by decreasing order of utility.



Health losses were found for all five dimensions. The proportion of individuals without any problems in mobility, self-care, and usual activities decreased by 19%, 7%, and 31%, respectively, between 2015 and 2018. In 2015, before the dam collapse, 5%, 1%, and 3% reported moderate problems in these dimensions. In 2018, these proportions increased to 22%, 7% and 31%, respectively (p-value<0.001). The greatest changes were observed for the anxiety/depression dimension, followed by pain/discomfort. The prevalence of individuals with no problems in these dimensions reduced from 89% and 76% to 30% and 28% after the collapse (p-value<0.001). In contrast, the proportion of individuals with severe anxiety/depression and pain/discomfort, about 1% before the tragedy, increased to 11% and 23%, respectively (p-value<0.001) (**Figure 3**).

Figure 3. The proportion of affected individuals in each dimension and level of the EQ-5D-3L scale before and three years after the dam collapse



Before the dam collapse

After the dam collapse

Note: Mob=Mobility; SC=Self-Care; UA=Usual activities; PD=Pain/Discomfort; AD=Anxiety/Depression

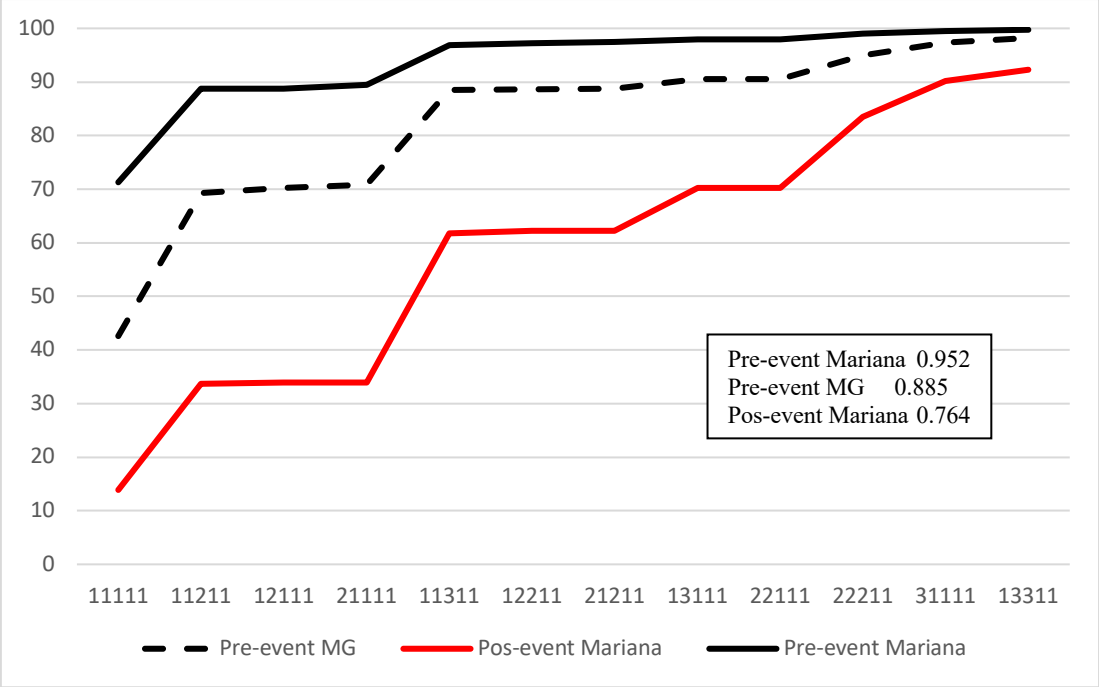
Considering the whole sample, the mean difference in utility was -19.5%, ranging between -122% (biggest loss) and 65% (biggest gain). In terms of utility, the mean difference was -0.188, and the biggest loss was -1.22. Negative values indicate a health loss. On average, women showed higher losses than men (-21.4% vs. -17.5, p-value=0.004) or in utility values (-0.206 vs -0.169 p-value=0.04). As the compensation for the HRQoLloss is expected to be claimedonly by individuals that had some loss in their health state,the conditional mean loss was -0.26. **Table 3** reports HRQoL losses in utilities and percentage losses considering Mariana retrospective EQ-5D health states as a proxy for pre-event. Women and the elderly reported larger health losses than men and the young individuals, ranging from -24% for 15 to 49 years old men until-37% for women above 60 years old (**Table 3**).

Table 3.Absolute values of Health-Related Quality of LifeLoss (%)

Sex	Age Groups	Allobservations		Considering only individuals with some HRQoL losses	
		Δ Utility	**Δ% Utility**	**Δ Utility**	**Δ% Utility**
Female	15 a 49	-0.19	-19.8	-0.24	-24.5
	50 a 59	-0.21	-21.0	-0.32	-33.2
	60 +	-0.25	-27.6	-0.33	-37.2
Male	15 a 49	-0.16	-16.4	-0.24	-24.1
	50 a 59	-0.17	-18.4	-0.27	-28.4
	60 +	-0.20	-21.1	-0.32	-34.6

The second estimation for HRQoL loss was built using standardized scores distribution for MG as a proxy for pre-event health status. In this case, HRQoL loss is estimated, considering only affected individuals aged between 18-64 years old. **Figure 3** reports the EQ-5D health states distribution for both potential measures of pre-event and for post-dam collapse. As expected, the HRQoL loss is smaller when the standardized MG distribution is used as a pre-event measure as compared to the retrospective measure.

Figure 3. Cumulative distribution of EQ-5D-3L health states of the affected individuals before and three years after the dam collapse considering two potential measures for pre-event sorted by decreasing order of utility



4 DISCUSSION

This paper evaluatedHRQoL loss due to the dam collapse at Samarco iron ore mine. We found catastrophic losses for affected individuals. Around 74% of affected individuals reported health losses after the dam collapse, accounting for a conditional average loss of 27%. Before the disaster, the average health utility was 0.95, decreasing to 0.759 after the disaster considering the retrospective measure as the pre-event distribution. The majority of studies evaluating HRQoL loss in technological disasters use SF-36. Sabucedo et al.[41]analyzed health impacts of the 2002 Prestige oil disaster in Spain and found that the decrease in general health was 6.61 score points larger among individuals with a high level of exposure compared to those with a low level of exposure, resulting in a loss of around 9.21%. Cherry et al. [21] also found health losses among individuals who were severely affected by the Katrina and Rita Hurricanes and the 2010 BP Deepwater Horizon oil spill. According to the authors, the current coastal fishermen who had their economic activities affected by one of these disasters were 76% less likely to present higher physical and mental SF-36 subscales scores.

Few studies have been found using EQ-5D to estimate health impacts due to natural disasters [45,46]. Hugelius et al. [45] analyzed health impacts among the survivors and health professionals thirty months after a natural disaster in the Philippines. Main findings showed that Anxiety/Depression and Pain/Discomfort were the most affected dimensions after 30 months: 19% and 13% of individuals reported having moderate or severe problems. In Mariana these figures after the dam collapse were extremely higher, 72% and 69%, respectively.

The quality of life of the affected individuals after the Samarcodam collapse is comparable to patients living under severe health conditions. For Brazil some studies using the same EQ-5D value sets [49] found a mean utility equal to 0.88 for patients living with HIV [50], 0.5 for patients with Parkinson's Disease and 0.7 for their caregivers [51], 0.74for patients with Diabetes mellitus (DM) type 1 and 0.66for patients with DM type 2 [52], 0.73, 0.69 and 0.84 for renal impaired patients in treatment with hemodialysis, peritoneal dialysis and kidney transplant, respectively [53].This evidence shows the severe health conditions experienced by affected individuals after the dam collapse in Mariana.

The health effects of the dam collapse were even more severe for older individuals. Our results showed that individuals over 60 years old had a higher HRQoL loss compared to the whole population. Among those who experienced some HRQoL loss, the average $EQ\text{-}5D_{index}$ score was equal to 0.91 before the dam collapse anddeeply decreased to 0.59 after the tragedy. This severe negative effect observed for older individuals is associated with theirpoor ability to adapt and recover from traumas[19,54]. These losses are comparable to patients with severe chronic conditions. Ock et al.[55], using EQ-5D-3L, estimated differences in utility weights between healthy controls and ill people along the life cycle. For men over 80 years with stroke, for instance, the difference in utility weights was 0.34 in Korea.

The analysis of EQ-5D health dimensions showed different consequences in terms of the level of severity. Anxiety/depression and pain/discomfort were the domains with thelargest differences in the distribution after the dam collapse.PTSDisamong the most commonly reported health consequences observed in individuals exposed to technological disasters[56]. These health consequences are expected since technological disasters strongly disrupt social networks and economic activities. Furthermore, the healing process is delayed by the slow response of the stakeholders[7,9,20]. An important adverse health effect was also observed for the usual activities and the mobility dimensions. As already mentioned, the affected population used to live in rural communities based on family agricultural activities, and their lifestyle was deeply dependent on environmental and social conditions. After the dam collapse, they were abruptly displaced to theurban area of Mariana and confined in temporary lodges. In this new context, they were deprived of any agricultural or community activities.

Some limitations of this study should be addressed. The first one concerns the GRDof affected individuals from which our sampled individuals were randomly selected. The identification of victims of technological and natural disasters is one of the main challenges for the recovery and repairing process [20]. In the Mariana case, individuals voluntarily adhered to the GRD organized by Renova with support of non-governmental institutions, in particular, Caritas-MG. This process has been too long and still incomplete. Besides, some of the registered families were not directly affected by the dam collapse since they did not live there at the timeof the disaster. Two different reasons explain their inclusion in the General Registry. First, some of them only had properties in the affected communities. Second, some relatives were not permanent

residents of the households but were eligible to receive the monetary compensation. Nevertheless, the General Registry is a more accurate identification method than the usual approach that relies on exposure metrics and household distance to the event to define the affected individuals.

The second limitation is related to the absence of pre-event information about the health status of the affected population. To overcome this lack of data, we made use of two pre-event measures. In comparison with the standardized MG adult population, it was estimated that abetter pre-event health status existed amongst affected individuals 71% of whom were deemed to have no problems on any of the EQ-5D dimensions compared with 43% for the general population. Accordingly, on average, the pre-event EQ-$5D_{index}$ values are relatively higher among the victims.

There are at least two possible explanations that might account for these health status differences. The first one concerns the characteristics of the two populations. Differences in age-sex distribution were accounted for by the standardization procedure. However, other non-observable differences could play a role. For instance, before the dam collapse, most of the affected individuals lived in rural areas while the MG sample comprises only urban areas. Therefore, it could be the case that the pre-event HRQoL of the affected individuals was higher than the average MG values.

The second explanationregards the reference period defined for both studies to evaluate health status. In the MG study, respondents were asked to assess their current health status whereas in Mariana pre-event health status relies on retrospective information. Therefore, there might be a recall bias in reporting the past health status [57,58]. This effect, though, is expected to be small insofar as the elapsed time since the event is only three years. Besides, recall bias may not be uniform among health states. Respondents could have more difficulties remembering mild health problems and be more aware of the severe conditions due to the adverse consequences on their wellbeing. The analysis by dimensions shows that the main differences between the two samples are observed for pain/discomfort and anxiety/depression. While the proportion of individuals without problems in both dimensions is around 72% in the Mariana sample, for the general adult population, this percentage is 46%.

Retrospective self-reported health may also be affected by changes in the perception of individuals. This phenomenon, known as *response shift*, is observed due to the individuals' experiences through their life cycle [58]. According to the response shift

theory, by using retrospective health evaluations, individuals would have more information when making judgments about their past health as well as the same anchorage when evaluating their health status before and after the event [57,59]. The majority of empirical evidence for response shift is associated with positive events such as medical intervention including the intake of medicines, surgeries, and rehabilitation programs. According to longitudinal studies, average HRQoL scores at the beginning of medical treatment tend to be higher for evaluations that occurred at that period. After being under treatment, the patients' judgments about their initial conditions are downscaled[59,60]. The main explanation for this change is due to the ability of individuals toadapt to adverse conditions imposed by the disease before treatment. After recovering their health, looking backward, patients would have a better perception of their past limitations, especially compared to their current condition [57].

In contrast, under negative circumstances, such as injuries, individuals tend to assign higher values to their past health status than if the evaluation was taken before the traumatic event [59]. Current adverse conditions will make individuals more optimistic about their pre-event health status. For the affected population of Mariana in particular, in the light of the response shift theory individuals would have a greater optimism regarding their past health status, which justifies the genuine feeling of enhanced HRQoL loss.

This paper opens an opportunity to use EQ-5D to measure HRQoL losses and widens its scope far beyond Health Technological Assessment.The use of EQ-5D-3L as a retrospective measure confirms its potential value for studies when longitudinal data is not an option. Unfortunately, Brazil has recently experienced another dam collapse of large proportions in Brumadinho, Minas Gerais. More than two hundred people immediately died, others are still missing, and several families lost their homes. As we write this study a third dam from the Vale iron ore mine, located in the municipality of Barão de Cocais, also in the state of Minas Gerais, is in the imminenceofa collapse. Despite the anticipated announcement and training for evacuation conducted by Vale S. A., health loss is already accumulating as individuals in the risk area experience the stress of the feeling of imminent loss of their cultural heritage, the surrounding environment and ultimately their own lives. All these local communities are struggling with environmental and socioeconomic consequences. Our findings can help the

assessment of health damages in Brumadinho and put EQ-5D as a potential metricfor this type of health loss estimation.

5 REFERENCES

1. Zhouri A, Valencio N, Oliveira R, Zucarelli M, Laschefski K, Santos AF. O desastre da Samarco e a política das afetações: classificações e ações que produzem o sofrimento social. Cienc Cult [Internet]. 2016 Sep [cited 2019 May 14];68(3):36–40. Available from: http://cienciaecultura.bvs.br/scielo.php?script=sci_arttext&pid=S0009-67252016000300012&lng=pt&tlng=pt

2. Neves M de CL das, Roque M, Freitas AA, Garcia F. PRISMMA: Pesquisa sobre a Saúde Mental das Famílias Atingidas pelo Rompimento da Barragem do Fundão em Mariana. Belo Horizonte; 2018.

3. Faria MP de. Impactos do incidente de Mariana. Rev Bras Med do Trab [Internet]. 2018 [cited 2019 May 14];16(s1):32–32. Available from: http://www.rbmt.org.br/details/344/pt-BR/impactos-do-incidente-de-mariana

4. Sandifer PA, Walker AH. Enhancing Disaster Resilience by Reducing Stress-Associated Health Impacts. Front Public Heal [Internet]. 2018 Dec 21 [cited 2019 May 14];6:373. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2018.00373/full

5. Gill DA, Ritchie LA. Contributions of Technological and Natech Disaster Research to the Social Science Disaster Paradigm. In Springer, Cham; 2018 [cited 2019 May 14]. p. 39–60. Available from: http://link.springer.com/10.1007/978-3-319-63254-4_3

6. Couch SR, Kroll-Smith JS. Controllability, social breakdown and technological disasters: The case of the centralia coal mine fire. In: Natural and Technological Disasters: Causes, Effects and Preventive Measures. Pitsburg: Pennsylvania Academy of Science; 1992.

7. Buckingham-Howes S, Holmes K, Glenn Morris J, Grattan LM. Prolonged

Financial Distress After the Deepwater Horizon Oil Spill Predicts Behavioral Health. J Behav Health Serv Res [Internet]. 2018 Apr 13 [cited 2019 May 14];46(2):294–305. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29536343

8. Grattan LM, Brumback B, Roberts SM, Buckingham-Howes S, Toben AC, Morris G. “Bouncing back” after the Deepwater Horizon oil spill. Disaster Prev Manag An Int J [Internet]. 2017 Apr 3 [cited 2019 May 14];26(2):122–33. Available from: http://www.emeraldinsight.com/doi/10.1108/DPM-09-2016-0195

9. Picou JS, Martin CG. Long-Term Community Impacts of the Exxon Valdez Oil Spill: Patterns of Social Disruption and Psychological Stress Seventeen Years after the Disaster 1. 2007 [cited 2019 May 14]; Available from: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.383.6130

10. Bromet EJ, Havenaar JM, Guey LT. A 25 Year Retrospective Review of the Psychological Consequences of the Chernobyl Accident. Clin Oncol [Internet]. 2011 May [cited 2019 May 15];23(4):297–305. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21330117

11. Rung AL, Gaston S, Oral E, Robinson WT, Fontham E, Harrington DJ, et al. Depression, Mental Distress, and Domestic Conflict among Louisiana Women Exposed to the Deepwater Horizon Oil Spill in the WaTCH Study. Environ Health Perspect [Internet]. 2016 [cited 2019 May 14];124(9):1429–35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27164620

12. Loganovsky K, Havenaar JM, Tintle NL, Guey LT, Kotov R, Bromet EJ. The mental health of clean-up workers 18 years after the Chernobyl accident. Psychol Med [Internet]. 2008 Apr 30 [cited 2019 May 14];38(4):481–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18047772

13. De Soir E, Versporten A, Zech E, Van Oyen H, Mylle J, Kleber R, et al. Does exposure type impact differentially over time on the development of mental health disturbances after a technological disaster? Arch Public Health [Internet]. 2015 [cited 2019 May 14];73(1):20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25897399

14. Bromet EJ, Guey LT, Taormina DP, Carlson GA, Havenaar JM, Kotov R, et al.

Growing up in the shadow of Chornobyl: adolescents' risk perceptions and mental health. Soc Psychiatry Psychiatr Epidemiol [Internet]. 2011 May 11 [cited 2019 May 14];46(5):393–402. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20221882

15. Ginzburg HM. The psychological consequences of the Chernobyl accident--findings from the International Atomic Energy Agency Study. Public Health Rep [Internet]. 1993 [cited 2019 May 14];108(2):184–92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8464974

16. Cwikel J, Abdelgani A, Goldsmith JR, Quastel M, Yevelson II. Two-year follow up study of stress-related disorders among immigrants to Israel from the Chernobyl area. Environ Health Perspect [Internet]. 1997 Dec [cited 2019 May 14];105 Suppl 6(Suppl 6):1545–50. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9467080

17. Joseph NB, Reisfeld D, Tirosh E, Silman Z, Rennert G. Neurobehavioral and Cognitive Performances of Children Exposed to Low-Dose Radiation in the Chernobyl Accident: The Israeli Chernobyl Health Effects Study. Am J Epidemiol [Internet]. 2004 Sep 1 [cited 2019 May 14];160(5):453–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15321842

18. Cherry KE, Sampson L, Galea S, Marks LD, Stanko KE, Nezat PF, et al. Spirituality, Humor, and Resilience After Natural and Technological Disasters. J Nurs Scholarsh [Internet]. 2018 Sep [cited 2019 May 14];50(5):492–501. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30058284

19. Cherry KE, Sampson L, Galea S, Marks LD, Baudoin KH, Nezat PF, et al. Health-Related Quality of Life in Older Coastal Residents After Multiple Disasters. Disaster Med Public Health Prep [Internet]. 2017 Feb 15 [cited 2019 May 14];11(1):90–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27974075

20. Lucchini RG, Hashim D, Acquilla S, Basanets A, Bertazzi PA, Bushmanov A, et al. A comparative assessment of major international disasters: the need for exposure assessment, systematic emergency preparedness, and lifetime health care. BMC Public Health [Internet]. 2017 [cited 2019 May 14];17(1):46. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28061835

21. Cherry KE, Sampson L, Nezat PF, Cacamo A, Marks LD, Galea S. Long-term psychological outcomes in older adults after disaster: relationships to religiosity and social support. Aging Ment Health [Internet]. 2015 May 4 [cited 2019 May 14];19(5):430–43. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25078872

22. Lucchini RG, Crane MA, Crowley L, Globina Y, Milek DJ, Boffetta P, et al. The World Trade Center health surveillance program: results of the first 10 years and implications for prevention. G Ital Med Lav Ergon [Internet]. 2012 [cited 2019 May 14];34(3 Suppl):529–33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23405708

23. Bei B, Bryant C, Gilson K-M, Koh J, Gibson P, Komiti A, et al. A prospective study of the impact of floods on the mental and physical health of older adults. Aging Ment Health [Internet]. 2013 Nov [cited 2019 May 14];17(8):992–1002. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23711204

24. Brasil. Termo de Transação de Ajustamento de Conduta [Internet]. 2016. Available from: https://www.samarco.com/wp-content/uploads/2016/07/TTAC-FINAL.pdf

25. Samarco. Estatuto da Fundação Renova [Internet]. Belo Horizonte: Samarco; 2016. Available from: https://www.fundacaorenova.org/wp-content/uploads/2016/11/estatuto-registrado.pdf

26. Morris JG, Grattan LM, Mayer BM, Blackburn JK, Blackburn JK. Psychological responses and resilience of people and communities impacted by the deepwater horizon oil spill. Trans Am Clin Climatol Assoc [Internet]. 2013 [cited 2019 May 14];124:191–201. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23874022

27. Green BL, Korol M, Grace MC, Vary MG, Leonard AC, Gleser GC, et al. Children and Disaster: Age, Gender, and Parental Effects on PTSD Symptoms. J Am Acad Child Adolesc Psychiatry [Internet]. 1991 Nov [cited 2019 May 14];30(6):945–51. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1757444

28. Green BL, Grace MC, Vary MG, Kramer TL, Gleser GC, Leonard AC. Children of Disaster in the Second Decade: A 17-Year Follow-up of Buffalo Creek

Survivors. J Am Acad Child Adolesc Psychiatry [Internet]. 1994 Jan [cited 2019 May 14];33(1):71–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8138524

29. Instituto Brasiiro de Mineração. Panorama da Mineração em Minas Gerais. Brasília; 2015.

30. Viinamäki H, Kumpusalo E, Myllykangas M, Salomaa S, Kumpusalo L, Kolmakov S, et al. The Chernobyl accident and mental wellbeing--a population study. Acta Psychiatr Scand [Internet]. 1995 Jun [cited 2019 May 15];91(6):396–401. Available from: http://www.ncbi.nlm.nih.gov/pubmed/7676837

31. Havenaar JM, Van den Brink W, Van den Bout J, Kasyanenko AP, Poelijoe NW, Wholfarth T, et al. Mental health problems in the Gomel region (Belarus): an analysis of risk factors in an area affected by the Chernobyl disaster. Psychol Med [Internet]. 1996 Jul [cited 2019 May 15];26(4):845–55. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8817720

32. Havenaar JM, Rumyantzeva GM, van den Brink W, Poelijoe NW, van den Bout J, van Engeland H, et al. Long-Term Mental Health Effects of the Chernobyl Disaster: An Epidemiologic Survey in Two Former Soviet Regions. Am J Psychiatry [Internet]. 1997 Nov [cited 2019 May 15];154(11):1605–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9356574

33. Havenaar J, Rumyantzeva G, Kasyanenko A, Kaasjager K, Westermann A, van den Brink W, et al. Health effects of the Chernobyl disaster: illness or illness behavior? A comparative general health survey in two former Soviet regions. Environ Health Perspect [Internet]. 1997 Dec [cited 2019 May 15];105 Suppl 6(Suppl 6):1533–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9467078

34. Bromet EJ, Goldgaber D, Carlson G, Panina N, Golovakha E, Gluzman SF, et al. Children's Well-being 11 Years After the Chornobyl Catastrophe. Arch Gen Psychiatry. 2000;57:563–71.

35. Green BL, Lindy JD, Grace MC, Gleser GC, Leonard AC, Korol M, et al. Buffalo Creek survivors in the second decade: stability of stress symptoms. Am J Orthopsychiatry [Internet]. 1990 Jan [cited 2019 May 15];60(1):43–54. Available from: http://www.ncbi.nlm.nih.gov/pubmed/2305844

36. Green BL, Lindy JD, Grace MC, Leonard AC. Chronic posttraumatic stress disorder and diagnostic comorbidity in a disaster sample. J Nerv Ment Dis [Internet]. 1992 Dec [cited 2019 May 15];180(12):760–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1469374

37. Annang L, Wilson S, Tinago C, Wright Sanders L, Bevington T, Carlos B, et al. Photovoice. Qual Health Res [Internet]. 2016 Jan 20 [cited 2019 May 15];26(2):241–51. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25794525

38. Bromet EJ, Parkinson DK, Dunn LO. Long-term Mental Health Consequences of the Accident at Three Mile Island. Int J Ment Health [Internet]. 1990 Jun 4 [cited 2019 May 15];19(2):48–60. Available from: https://www.tandfonline.com/doi/full/10.1080/00207411.1990.11449162

39. Davison LM, Weiss L, O'Keeffe M, Baum A. Acute stressors and chronic stress at Three Mile Island. J Trauma Stress [Internet]. 1991 Oct 1 [cited 2019 May 15];4(4):481–93. Available from: http://doi.wiley.com/10.1002/jts.2490040404

40. Boer F, Smit C, Morren M, Roorda J, Yzermans J. Impact of a technological disaster on young children: A five-year postdisaster multiinformant study. J Trauma Stress [Internet]. 2009 Dec [cited 2019 May 15];22(6):n/a-n/a. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19824065

41. Sabucedo JM, Arce C, Senra C, Seoane G, Vázquez I. Symptomatic profile and health-related quality of life of persons affected by the Prestige catastrophe. Disasters [Internet]. 2010 Jul [cited 2019 May 15];34(3):809–20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20345463

42. Fernandez WG, Galea S, Miller J, Ahern J, Chiang W, Kennedy EL, et al. Health Status among Emergency Department Patients Approximately One Year after Consecutive Disasters in New York City. Acad Emerg Med [Internet]. 2005 Oct 1 [cited 2019 May 15];12(10):958–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16204139

43. Rocha EM, Moraes LGM de, Almeida LV de, Dalvi LR, Andriato LC, Bergamaschi LK, et al. Impacto do rompimento da barragem em Mariana–MG na saúde da população ribeirinha da cidade de Colatina–ES. Tempus Actas de Saúde Coletiva [Internet]. 2016 Nov 21 [cited 2019 May 15];10(3):31. Available from:

http://www.tempus.unb.br/index.php/tempus/article/view/1902

44. Vormittag E da MPA de A, Oliveira MA de, Gleriano JS. Health evaluation of the Barra Longa population affected by the disaster in Mariana County. Ambient Soc [Internet]. 2018 Nov 8 [cited 2019 May 15];21(0). Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1414-753X2018000100405&lng=en&tlng=en

45. Hugelius K, Gifford M, Örtenwall P, Adolfsson A. Health among disaster survivors and health professionals after the Haiyan Typhoon: a self-selected Internet-based web survey. Int J Emerg Med [Internet]. 2017 Dec [cited 2019 Jun 17];10(1):13. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28357722

46. Khachadourian V, Armenian HK, Demirchyan A, Goenjian A. Loss and psychosocial factors as determinants of quality of life in a cohort of earthquake survivors. Health Qual Life Outcomes [Internet]. 2015 Feb 6 [cited 2019 Jun 17];13(1):13. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25890107

47. EuroQol. EuroQol--a new facility for the measurement of health-related quality of life. Health Policy (New York) [Internet]. 1990/11/05. 1990;16(3):199–208. Available from: http://www.ncbi.nlm.nih.gov/pubmed/10109801

48. Thompson SK. Sample Size for Estimating Multinomial Proportions. Am Stat [Internet]. 1987 Feb [cited 2019 Jun 11];41(1):42–6. Available from: http://www.tandfonline.com/doi/abs/10.1080/00031305.1987.10475440

49. Andrade MV, Noronha K, Kind P, Maia AC, Menezes RM de, Reis CDB, et al. Societal Preferences for EQ-5D Health States from a Brazilian Population Survey. Value Heal Reg Issues. 2013;2:405–15.

50. Costa J de O, Pearson SA, Acurcio F de A, Bonolo P de F, Silveira MR, Ceccato M das GB. Health-related quality of life among HIV-infected patients initiating treatment in Brazil in the single-tablet regimen era. AIDS Care [Internet]. 2019 May 4 [cited 2019 Jun 12];31(5):572–81. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30727749

51. Carod-Artal FJ, Mesquita HM, Ziomkowski S, Martinez-Martin P. Burden and health-related quality of life among caregivers of Brazilian Parkinson's disease patients. Parkinsonism Relat Disord [Internet]. 2013 Nov 1 [cited 2019 Jun

13];19(11):943–8. Available from: https://www.sciencedirect.com/science/article/pii/S135380201300223X

52. Mata AR da, Álvares J, Diniz LM, Ruberson Ribeiro da Silva M, Alvernaz dos Santos BR, Guerra Júnior AA, et al. Quality of life of patients with Diabetes Mellitus Types 1 and 2 from a referal health centre in Minas Gerais, Brazil. Expert Rev Clin Pharmacol [Internet]. 2016 May 3 [cited 2019 Jun 13];9(5):739–46. Available from: http://www.tandfonline.com/doi/full/10.1586/17512433.2016.1152180

53. Alvares J, Almeida AM, Szuster DAC, Gomes IC, Andrade EIG, Acurcio F de A, et al. Fatores associados à qualidade de vida de pacientes em terapia renal substitutiva no Brasil. Cien Saude Colet [Internet]. 2013 Jul [cited 2019 Jun 13];18(7):1903–10. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-81232013000700005&lng=pt&tlng=pt

54. Menezes R de M, Andrade MV, Noronha KVM de S, Kind P. EQ-5D-3L as a health measure of Brazilian adult population. Qual Life Res [Internet]. 2015 Nov 21 [cited 2019 Jun 13];24(11):2761–76. Available from: http://link.springer.com/10.1007/s11136-015-0994-7

55. Ock M, Han JW, Lee JY, Kim S-H, Jo M-W. Estimating Quality-Adjusted Life-Year Loss Due to Noncommunicable Diseases in Korean Adults through to the Year 2040. Value Heal [Internet]. 2015 Jan [cited 2019 May 15];18(1):61–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25595235

56. Neria Y, Nandi A, Galea S. Post-traumatic stress disorder following disasters: a systematic review. Psychol Med [Internet]. 2008 Apr 6 [cited 2019 May 15];38(4):467–80. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17803838

57. Norman G. Hi! How are you? Response shift, implicit theories and differing epistemologies. Qual Life Res [Internet]. 2003 [cited 2019 May 15];12(3):239–49. Available from: http://link.springer.com/10.1023/A:1023211129926

58. Blome C, Augustin M. Measuring Change in Quality of Life: Bias in Prospective and Retrospective Evaluation. Value Heal [Internet]. 2015 Jan 1 [cited 2019 May 16];18(1):110–5. Available from:

https://www.sciencedirect.com/science/article/pii/S1098301514047329

59. Watson WL, Ozanne-Smith J, Richardson J. Retrospective baseline measurement of self-reported health status and health-related quality of life versus population norms in the evaluation of post-injury losses. Inj Prev [Internet]. 2007 Feb 1 [cited 2019 May 15];13(1):45–50. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17296689

60. Wilson R, Derrett S, Hansen P, Langley J. Retrospective evaluation versus population norms for the measurement of baseline health status. Health Qual Life Outcomes [Internet]. 2012 Jun 14 [cited 2019 May 16];10(1):68. Available from: http://hqlo.biomedcentral.com/articles/10.1186/1477-7525-10-68