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Association of Drowning Mortality with Preventive Interventions: A Quarter of a Million Deaths Evaluation in Brazil

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Cover Page Footnote

The authors gratefully acknowledge the contribution of Jonathan Webber for his English review and the Board of Directors of the Brazilian Lifesaving Society (SOBRASA) for having actively participated providing information concerning prevention and water safety interventions at their states. Compliance with Ethical Standards The authors declare that they have no conflict of interest. This research uses aggregated and secondary data from a database made public by a state entity. For this reason, it is exempted from ethical approval, as recommended by Resolution of the National Health Council (CNS) n ° 466/12. Additionally, data are not individually identifiable and does not include private information. Hence, since this study doesn't constitute research involving human subjects it is exempt from informed consent.

Abstract

In 2015, drowning in Brazil was responsible for 6,043 deaths and was the second leading cause of death in children. Although several prevention strategies have been promoted to reduce drowning, most are still based on low levels of evidence. This study evaluated the effectiveness of prevention and water safety interventions in reducing drowning mortality. Data obtained from the National Mortality System for 36 years were split in two time periods to allow the comparison of drowning mortality numbers before and after implementation of SOBRASA's drowning prevention and water safety programs and to check for any positive effects attributable to such programs. To assess differences between the two periods, a "drowning water safety score" (DSS) was estimated and compared to mortality/100,000 of population. There were 258,834 drowning deaths over 36 years. A significant decrease of 27% in drowning rates (5.2 to 3.8/100,000; $p < 0.05$) was observed when comparing the pre and post-preventive interventions time periods. Males died 5.3 times more frequently than females, and mortality was higher in the 15-19-year age group (16.4%; 4.7/100,000) than in other age groups. A linear dependent association was observed between prevention and water safety interventions and years affiliated to the national lifesaving organization (SOBRASA). A strong and significant association (OR=241.7; CI95% [9.0–64.84]) between DSS and drowning reduction was observed. The DSS is a fundamental measure for institutions/municipalities/states/countries to estimate the efforts needed to achieve their drowning reduction goals. From this study, a DSS above 100 (i.e.: 10 actions implemented over 10 years) was able to reduce drowning deaths by as much as 2.3% a year.

Keywords: drowning, prevention, mortality, trauma, water safety, drowning water safety score (DSS)

Introduction

Drowning is a serious and neglected public health threat claiming the lives of 372,000 people a year worldwide (WHO, 2014)¹. More than 90% of those deaths occur in low- and middle-income countries and children are disproportionately at risk. Prevention is the key message being advocated by the World Health Organization (WHO) (WHO, 2014).

Vast natural waterways and an extensive coastline expose Brazilian citizens to water incidents daily. Eighty-six percent of its population is urban and 25% is younger than 15 years old (Szpilman, 2017). Public awareness of drowning as a serious public health issue goes back to 1910 in Brazil, when people started to use coastal beaches for recreational activities. At that time, local fishermen were responsible for keeping people safe in and around the water. In 2015, 201 million people lived in Brazil, and 1.1 million died in that year. External causes of death

were responsible for 13% of all deaths and were the main cause of death for those aged less than 45 years. Drowning was responsible for 6,043 deaths (2.9/100,000 population) and was the second leading cause of death in children under 9 years old, the third among people aged 10 to 19 years and the fourth among people aged 20 to 25 years (Szpilman, 2017).

The country's first lifesaving service was founded in 1918 in the city of Rio de Janeiro. Since then, many other services have been established around the country. In 1985 the military firefighters took over responsibility for water rescue services in each federative state. Except for some civilian lifesaving services and pool lifeguards, Brazil has maintained these military firefighter-based lifeguarding services to this day.

The Brazilian Lifesaving Society (SOBRASA) was founded in 1995 by firefighters who were experts in lifesaving with the mission to reduce drowning mortality and morbidity through implementation of water safety programs grounded on prevention. Since then, its mission has been targeted to two main approaches: first, bringing together professionals with a duty of care in each state to exchange information and share the best practice on preparation, prevention, rescue and mitigation of drowning (Szpilman et al., 2016), and second, creating and promoting prevention and water safety campaigns and providing information that is freely available to all. Since its foundation in 1995, more than 30 different prevention and water safety programs comprising all aquatic scenarios, activities, and ages impacted by drowning have been created and promoted.

In its 2014 Global Report on Drowning, the World Health Organization (WHO) outlined 10 actions deemed to be effective, feasible, and scalable to reduce drowning¹. Although drowning prevention strategies have been widely described and promoted worldwide as the first and most important step in reducing mortality and morbidity (Szpilman, et al., 2016; Szpilman, et al., 2014), most evidence is still based on expert opinion grounded on a small number of studies. Only a few studies have addressed the effectiveness of drowning prevention programs (Brenner, et al., 2009; Bugeja & Franklin, 2013; Cummings, et al., 2011; Rahman, et al., 2009; Rahman, et al., 2012). The purpose of this study was to evaluate the association between implemented preventive and water safety actions and prevalence of drowning mortality in Brazil over a period of 36 years.

Method

Data were collated and analysed by SOBRASA for all 27 States of the Brazilian Federation over a 36-year period. Data were split in two time periods to allow the comparison of drowning mortality numbers before and after implementation of SOBRASA's drowning prevention and water safety programs and to check for any

positive effects attributable to such programs. Assuming that there would be a gradual increase in the number of drowning prevention programs implemented since SOBRASA'S foundation and that a 2-year gap is needed to observe any effect attributable to the programs' effectiveness on yearly drowning mortality, the cut-off point for the study periods was defined as the year corresponding to 2 years from SOBRASA's foundation (1997). Hence, the two periods ranged from 1980 to 1997 (18 years) and from 1998 to 2015 (18 years). A summary of all preventions and water safety programs and interventions delivered over the period of the study are given in supplementary material (Table 1).

Table 1. Drowning deaths per 100.000 population per state (Brazil) comparing the 2 different time periods.

States of Brazilian Federation	1980 to 1997	1998 to 2015	$\Delta\%$	p-value*
Acre (AC)	6,40	5,36	-16,18	0.705
Alagoas (AL)	3,91	4,97	27,01	0.000*
Amapá (AP)	10,94	8,81	-19,51	0.013*
Amazonas (AM)	5,51	6,67	20,96	0.000*
Bahia (BA)	4,05	4,05	-0,16	0.952
Ceará (CE)	2,65	4,39	65,66	0.000*
Distrito Federal (DF)	3,91	1,99	-49,06	0.000*
Espírito Santo (ES)	7,69	5,27	-31,44	0.000*
Goiás (GO)	5,12	3,74	-26,95	0.000*
Maranhão (MA)	1,62	2,66	64,68	0.000*
Mato Grosso (MT)	5,41	6,04	11,61	0.098
Mato Grosso do Sul (MS)	6,24	4,56	-26,90	0.000*
Minas Gerais (MG)	5,58	3,39	-39,29	0.000*
Pará (PA)	4,65	3,89	-16,26	0.016*
Paraíba (PB)	3,29	4,05	22,94	0.032*
Paraná (PR)	5,75	3,97	-31,01	0.000*
Pernambuco (PE)	4,89	4,29	-12,15	0.026*
Piauí (PI)	2,68	3,73	39,10	0.000*
Rio de Janeiro (RJ)	5,68	2,50	-55,91	0.000*
Rio Grande do Norte (RN)	2,96	4,22	42,56	0.000*
Rio Grande do Sul (RS)	5,93	3,72	-37,28	0.000*
Rondônia (RO)	10,27	5,89	-42,65	0.000*
Roraima (RR)	9,05	7,82	-13,51	0.275
Santa Catarina (SC)	7,22	4,57	-36,74	0.000*
São Paulo (SP)	6,23	3,16	-49,38	0.000*
Sergipe (SE)	4,69	5,14	9,62	0.277
Tocantins (TO)	1,81	4,63	155,98	0.000*

$\Delta\%$ (Percentage of the difference between the two periods); * significant difference ($p < 0.05$).

Drowning mortality data were obtained from the death certificates retrieved by the National Mortality Information System (DATASUS, www.datasus.gov.br), using the International Classification of Diseases (ICD) – ICD-9 for 1980 to 1995 and ICD-10 for 1996 to 2015. Since every death is required to be registered on a death certificate, the quality of data on drowning deaths in Brazil is high. Drowning mortality rates per 100,000 of population were determined based on yearly population census estimates.

A “drowning water safety score” (DSS) to measure the strength of the interventions implemented was estimated for each State by multiplying the number of years of affiliation to SOBRASA by the number of water safety interventions [preparation/education and/or prevention (active and reactive)] conducted in that state (Szpilman et al., 2016). This coefficient was used to rank the affiliated member states and served as an indication of their prevention and water safety promotion efforts. The DSS was categorized and differences among groups were considered statistically significant if $p < 0.05$. The number of drowning deaths per year for each state per 100,000 of population was compared between the two time periods and cross-tabulated with the DSS.

Since data were not normally distributed (Kolmogorov-Smirnov test), the non-parametric Mann-Whitney, Spearman correlation, and chi-square tests were used. Odds ratio, ratio, and cluster analysis also were used. A second analysis explored the distribution of cases of improvement, based on the delta – cases with delta significantly greater than zero corresponding to Gradient 1: drowning reduction, and cases with delta lower or equal to zero corresponding to Gradient 0: drowning increase or no change. This research was exempted from ethical approval, as recommended by Resolution of the National Health Council (CNS) n^o 466/12, because it used aggregated and secondary data from a database made public by a state entity.

Results

Between 1980 and 2015, 252,197 intentional and unintentional drowning deaths occurred in Brazil, averaging 7,005 deaths per year. Most drowning deaths (88% +/-5) were classified as unintentional, 10% were unknown intent, and 2% were intentional (0.7% homicide and 1.3% suicide). Cases of unknown intent decreased from 23% in 1980, to 8.6% in 2015. The incidence of unintentional cases decreased from 4.1 (1980) to 2.6 (2015) deaths per 100,000 of population over the 36-year period of the study. Among the unintentional drowning deaths, open water was the most frequent location of occurrence (41%) including beaches, rivers, lakes, ponds, waterfalls, and other aquatic areas.

Drowning deaths were higher among adolescents ages 15-19-years (16.4%), followed by people ages 20-24 (13%), 10-14 (10.5%), 25-29 (9.7%) and 1-4 years (8.6%). Considering all ages, males fatally drowned 5.3 times more frequently than females, representing 84% of all drowning deaths. Globally, swimming pools accounted for only 2% of cases with half of the cases occurring in residential pools. Among children ages 1 to 9 years, pools represented 53% of all deaths. Similarly, deaths occurring in bathtubs represented an even smaller proportion of the deaths (0.2%; 72% residential), but this percentage increased to as much as 38% of all drowning deaths when considering only the under 4 years old age group.

Comparing Two Periods of Data

A significant decrease of 29.7% ($p < 0.05$) in overall drowning rates per 100,000 population was observed when comparing the mean rates for the two periods, from 5.23 in the period 1980-1997 to 3.68 between 1998 and 2015 (Figure 1). No other significant differences among age groups, sex, and place of death were observed when comparing the two periods.

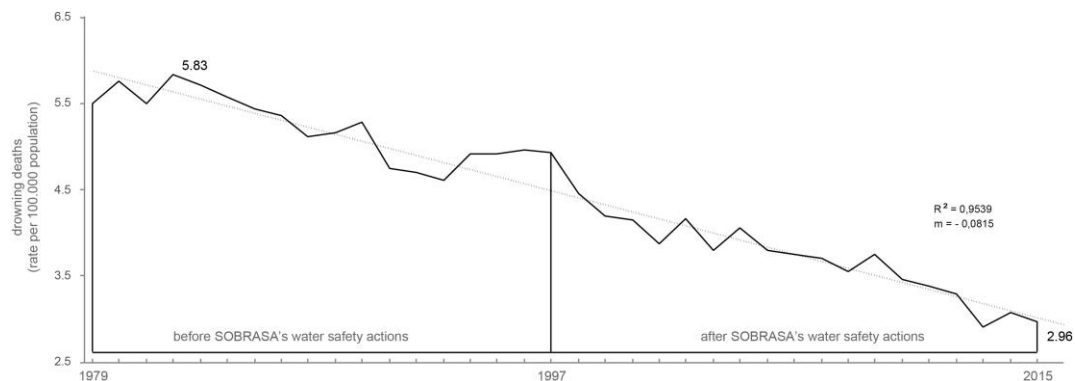


Figure 1. Drowning deaths in Brazil by year and rate per 100,000 of population between 1979 and 2015.

A relevant disparity in the numbers of drowning deaths was observed among the Brazilian regions and states, with drowning deaths rates per 100,000 population ranging from as low as 1.3 in the Federal District (Central Region) to as high of 10.9 in Amapa (Amazon Region). Fatal drowning data for each State are presented in Table 1 for the 2 periods studied.

Prevention and Water Safety Interventions and the Impact on Drowning Mortality

Table 2 summarizes the number of years affiliated to SOBRASA, number of prevention and water safety interventions, the drowning water safety score (DSS), and the percentage of change in drowning mortality between the two periods.

Table 2. Years of membership affiliation to SOBRASA and the number of water safety interventions over the second period evaluated (1998-2015).

State Name	SOBRASA membership affiliation years (a)	Number of water safety interventions (b)	rank score a x b (DSS)	Δ%	Grad	p-value*
Acre (AC) (*)	2	3	6	-16,18	No change	0.705
Alagoas (AL)	4	2	8	27,01	Increase	0.000*
Amapá (AP) (*)	1	1	1	-19,51	Reduction	0.013*
Amazonas (AM) (*)	0	0	---	20,96	Increase	0.000*
Bahia (BA)	17	5	85	-0,16	No change	0.952
Ceará (CE)	5	4	20	65,66	Increase	0.000*
Distrito Federal (DF) (*)	17	12	204	-49,06	Reduction	0.000*
Espírito Santo (ES)	12	8	96	-31,44	Reduction	0.000*
Goiás (GO) (*)	8	8	64	-26,95	Reduction	0.000*
Maranhão (MA)	2	1	2	64,68	Increase	0.000*
Mato Grosso (MT) (*)	12	5	60	11,61	No change	0.098
Mato Grosso do Sul (MS) (*)	3	2	6	-26,90	Reduction	0.000*
Minas Gerais (MG) (*)	15	6	90	-39,29	Reduction	0.000*
Pará (PA)	3	1	3	-16,26	Reduction	0.016*
Paraíba (PB)	2	3	6	22,94	Increase	0.032*
Paraná (PR)	15	11	165	-31,01	Reduction	0.000*
Pernambuco (PE)	17	8	136	-12,15	Reduction	0.026*
Piauí (PI) (*)	0	0	---	39,10	Increase	0.000*

Rio de Janeiro (RJ)	18	21	378	-55,91	Reduction	0.000*
Rio Grande do Norte (RN)	3	3	9	42,56	Increase	0.000*
Rio Grande do Sul (RS)	18	13	234	-37,28	Reduction	0.000*
Rondônia (RO) (*)	4	4	16	-42,65	Reduction	0.000*
Roraima (RR) (*)	3	3	9	-13,51	No change	0.275
Santa Catarina (SC)	17	14	238	-36,74	Reduction	0.000*
São Paulo (SP)	17	13	221	-49,38	Reduction	0.000*
Sergipe (SE)	2	3	6	9,62	No change	0.277
Tocantins (TO) (*)	3	2	6	155,98	Increase	0.000*

Legend: (*) In-land States (without coastline); DSS is the drowning water safety score, resulting from multiplying (a) with (b); $\Delta\%$ (percentage of drowning mortality difference between the first and second period per state); Grad (Gradient difference for mortality: black - no change; blue - reduction; red - increase); p-value significant <0.05 (non-parametric Mann-Whitney).

There was no difference between states, considering the number of prevention and water safety interventions implemented or socio-economic status when comparing inland States with coastal States ($p>0.05$). There was a significant positive correlation between the number of interventions and number of years affiliated to SOBRASA ($r_s=0,910$).

Figure 2 shows the relationship between the DSS and the rate of drowning mortality in each of the states analysed. The Brazilian Federation States on the bottom right of the figure showed positive changes more frequently than the Brazilian Federation States on the top left, which indicated that the more years affiliated, and the higher number of prevention and water safety interventions implemented, the greater the reduction of drowning deaths.

Table 3 presents a summary of the DSS and its relationships with mortality during the second period analyzed (18 years). There was a strong significant association between DSS and drowning mortality (OR 241.7, 95% CI: 9,0 – 6484; $p<0.05$).

Table 3. Correlation between the DSS and mortality throughout the second period of the study

DSS	Medium mortality in the second period (18 years)	Interpretation
0	30	Countries/states/municipalities where NO prevention and water safety interventions were implemented could expect an increase on drowning death by as much as 30% over 18 years or 1.7% yearly.
1 - 9	21	Countries/states/municipalities where only a few prevention and water safety interventions (i.e.; one over 6 years, or 2 over 3 years, or 4 over 2 years) were promoted could expect an increase on drowning death by as much as 21% over 18 years or 1.2% yearly.
16 - 20	12	Countries/states/municipalities where a few prevention and water safety actions (i.e.; one over 16 years, or 2 over 8 years, or 5 over 4 years) were promoted would still expect an increase on drowning death by as much as 12% over 18 years or 0.7% yearly.
60 - 64	-8	Countries/states/municipalities where extensive prevention and water safety actions (i.e.; two over 30 years, or 4 over 15 years or 10 over 6 years) were promoted could expect a decrease on drowning death by as much as 8% over 18 years or 0.4% yearly.
85 - 96	-24	Countries/states/municipalities where some longer prevention and water safety actions (i.e.; 4 over 22 years, or 8 over 11 years or 16 over 6 years) were promoted could expect a decrease on drowning death by as much as 24% over 18 years or 1.3% yearly.
136 - 238	-36	Countries/states/municipalities where prevention and water safety actions (i.e.; 10 over 14 years, or 20 over 7 years or 30 over 5 years) are promoted will expect a decrease on drowning death by as much as 36% over 18 years or 2% yearly.
>378	-56	Countries/states/municipalities where extensive long term prevention and water safety actions (i.e.; 10 over 38 years, or 20 over 19 years or 30 over 13 years) were promoted could expect a decrease on drowning death by as much as 56% over 18 years or 3.1% yearly.

Discussion

The significant decrease in drowning deaths observed between the two time periods indicated a negative correlation between water safety interventions and drowning deaths in Brazil. Since data regarding non-fatal drowning cases were mostly not collected and/or unreliable, it is unknown whether the number of such incidents also declined but we expected it to do so. Reported cases of unknown intent decreased over the 36 years of the study from 27% in 1980 to 11% in 2015. This might be a result of improved reporting and/or classification of drowning deaths over the time.

In general, drowning deaths were higher in male adolescents from less developed areas of the country indicating for yet another source of both gender and social inequality within Brazil. We feel the latent negative relationship between socioeconomic status and drowning deaths warrants further investigation. States without coastline were those who had the lowest DSS and, not surprisingly, were the most affected by drowning deaths in rivers, lakes, and dams.

There was a significant negative linear correlation between DSS and drowning mortality (Figure 2). Low ranking scores (i.e., below 50) appear to result in inconsistent changes in mortality rates with states achieving vastly different rates of success in the reduction of drowning mortality irrespective of ranking score. Instead, decreases in mortality in most states with high rank scores (i.e. above 60) were markedly more consistent. When considering only states with high DSS, the scores were found to be linked to the rate of change in mortality ($R^2 = 0.51$). For this group of states, a reduction in the rate of drowning mortality by 10% requires an increase in rank score of 65 points. This is the same as saying that a DSS above 100 (equivalent to 10 actions implemented throughout 10 years, for example) has the potential to cut drowning deaths by as much as 2.3% a year.

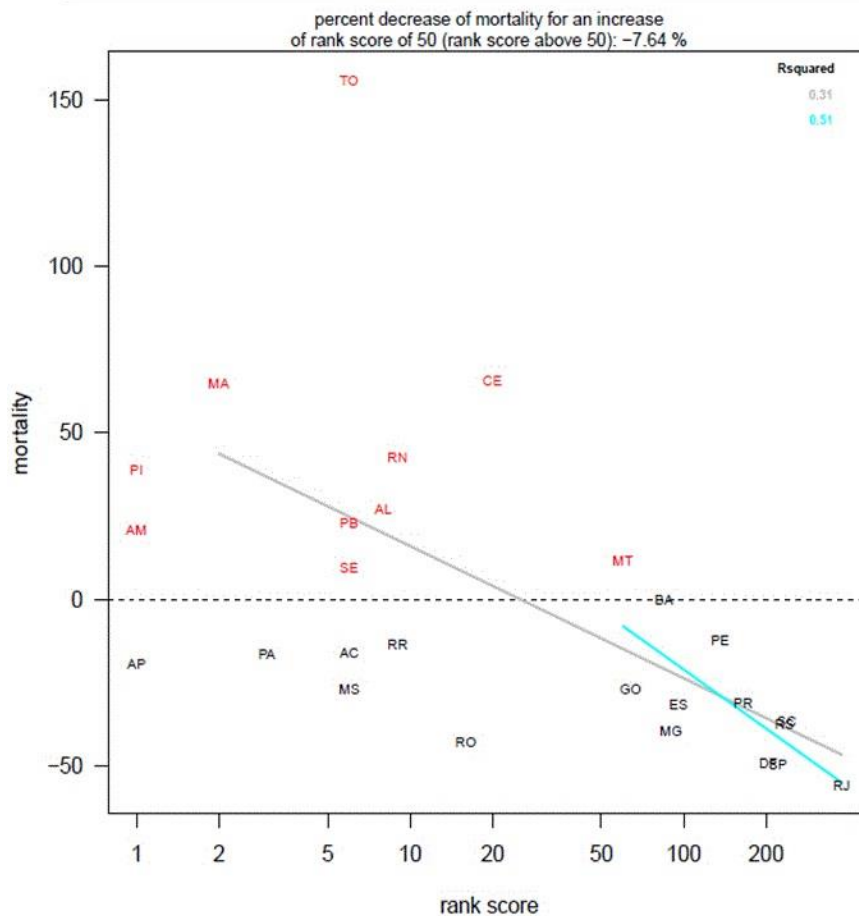


Figure 2. Relationship between rank score and change in the rate of drowning mortality in each of the states analyzed.

Limitations and Future Research Needs

In this study, some factors make it difficult to establish a causal relationship between the drowning deaths and the water safety interventions, namely: a) the methods to evaluate drowning prevention programs are only using the most severe drowning outcome (death) not considering the largest part of the drowning burden (non-fatal); b) educative and preventive measures take time to produce a measurable effect on rates, which can vary from place to place and time to time; c) seasonality is not taken in consideration. Additionally, the impact of such interventions across the population of interest including how many were affected, how deeply, how long the interventions last and what age group was most impacted were also not considered, and further investigation is needed.

Another important aspect to consider is the fact that numbers used in the analysis (both of deaths by drowning and of water safety interventions implemented) were the total for the whole state, therefore not considering intra-state variability. This means that a specific lifesaving service, which might be accomplishing excellent results locally, but is being considered just as a fraction of the state's death rates, won't have their local results accurately evaluated.

Further studies should consider other factors that might influence the measurement of the effectiveness of drowning prevention and water safety interventions including changes in the patterns of water exposure; the economic development (gross national product/per capita) in Brazil; the increase migration to urban areas; the increase in adult literacy rates offering more opportunity to education and awareness of water safety; family size reduction which may result in higher supervision rates; increasing rates of children in day-care and at schools with a consequent decrease in unsupervised water exposure; improvement of the firefighter's lifesaving service of prevention and rescue; and the improvements in pre-hospital and hospital medical care over the years.

Conclusions

This study has shown for the first time a strong relationship between the number of prevention and water safety interventions and drowning mortality. The DSS has, therefore, the potential to be used by drowning prevention agencies as a fundamental tool allowing them to estimate the efforts needed to achieve their drowning reduction goals.

The motivation resulting from joining a national lifesaving association that has brought together experts from the health and lifeguarding professional categories into one nationwide organization (e.g., SOBRASA), coupled with promoting and implementing numerous prevention and water safety interventions, has been associated with an important reduction in drowning mortality since 1997. This means that each year thousands fewer deaths occur from drowning. This reduction is not only due to the many different actions undertaken by individual lifesaving firefighter services, but can also be associated with the collective impact of SOBRASA as a national lifesaving association, and its leadership role in promoting and developing those interventions in Brazil.

It is very important for each lifesaving state service to evaluate their own operational area and determine exactly where the problems are and which solution(s) should be implemented to reduce death by drowning more effectively by using prevention and water safety programs.

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