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Heuristic bias in perception of medical students relating to out-of-hospital cardiac arrests

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Aim: The aim of this study was to assess the perceptions of medical students with respect to out-of-hospital cardiac arrests focusing on the frequency and survival and to identify potential problems in resuscitation education.
Methods: Fourth-year medical students in a six-year undergraduate educational system were asked to guess the number of out-of-hospital cardiac arrests with cardiac etiology per year in Japan, related data such as the one-month survival rate from out-of-hospital cardiac arrests with cardiac etiology and the number of deaths from traffic accidents for comparison. The guesses of students were compared with actual statistical data.
Results: The incidence of out-of-hospital cardiac arrests was clearly underestimated by the students compared to the real statistics. The median guessed number of out-of-hospital cardiac arrests ranged from 6000 to 20,000 while the real statistics ranged from 73.023 to 78.302 by year ($P < 0.001$ for all years). In contrast, the guessed number of deaths from traffic accidents was markedly overestimated: the median guessed number ranged from 8000 to 20,000 and the real statistics were 3694 to 4438 ($P < 0.001$ for all years). The one-month survival rate was also underestimated: the guessed number was 50% and the real rate was 11.5 to 13.5% ($P < 0.001$ for all years).
Conclusions: Out-of-hospital cardiac arrests are underestimated in frequency, and survival after an arrest is overestimated by medical students. To recognize and to understand the heuristic bias in perception of learners is needed for resuscitation education in addition to promote resuscitation skills of learners.

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health problem in every community.[1,2] To improve the currently insufficient application of cardiopulmonary resuscitation (CPR) for OHCA by laypersons, healthcare providers need to recognize the current status of OHCA and the importance of resuscitation.[3–5] Physicians are an important part of the community response to OHCA and should be major facilitators in promoting public awareness of OHCA, in addition to being key persons in deciding to initiate or terminate resuscitation, as well as carrying out resuscitation directly. Increase in survivors from OHCA has been shown in Japan.[6] This increase has been mainly discussed with the organization reform for public access defibrillation and emergency transport system not with physician skill and attitude for resuscitation.

Most medical schools teach CPR repeatedly in the curriculum, but the competency and literacy of medical students with regard to CPR has been reported to be insufficient.[7,8] One point of uncertainty is whether there is potential bias among medical students in awareness of OHCA. For example, the care for the patients suffered from road traffic accidents has been emphasized for a long time in the educational program for emergency care in the countries experienced industrial development era. Comparison of the students' awareness between OHCA and road traffic accidents might be verified. As for the care for OHCA, teaching is heavily biased toward CPR skills and the related theory, and educational strategies for resuscitation have been widely developed and evaluated.[9,10] The aim of our study was to assess perceptions of medical students

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relating to OHCA focusing on the frequency and survival and to identify potential problems concerning education on CPR and OHCA.

Methods

Participants

The participants were fourth-year undergraduate medical students in a six-year system who agreed to answer a self-administered questionnaire. The students had learned CPR by simulation scenario in a team approach in addition to skill training in the second year of the curriculum in a basic clinical course. Questionnaires were administered from 2013 to 2018, just before a lecture on resuscitation science in the emergency and critical care module. There was a different cohort of four-year students surveyed each year over a six-year period between 2013 and 2018.

Questionnaire

The students were asked to guess the number of deaths due to traffic accidents, number of persons with OHCAs with cardiac etiology, rate of bystander CPR, rate of survivors of OHCAs with cardiac etiology witnessed by bystanders, and number of emergency calls in the previous year in Japan. The questions were listed in this order (eTable 1). The students were asked to answer each question by writing a number that came to mind. We did not use a structured questionnaire such as a Likert Scale or a check-box system in order students would not change their decision by the frame of questions. We used free-descriptive type answer to avoid the framing effect and to assess real heuristic bias in the perception of students. This study was approved by the ethics committee of Kindai University (25–157).

Actual data

Real statistics were obtained from official Japanese Government reports that are available on the internet. The number of deaths due to traffic accidents was obtained from e-Stat.[11] Other data were obtained from the annual report of the Fire and Disaster Management Agency of Japan.[12]

Analyses

The response rate of students who answered the questions and the sex ratio were assessed using Cochrane-Armitage tests to examine annual trends. Age was assessed by Jonckheere-Terpstra test. The number of missing values for each item are shown in Supplementary Table 1. Annual trends in real statistics were assessed by Jonckheere-Terpstra test. Medians of numbers guessed by students for each item and in each year were compared with the real data. Significant differences between medians and real data were assessed using a one-sample Wilcoxon signed-rank test.

To examine the patterns of the wide range of distribution of guessed numbers of OHCAs, these numbers were reduced to single digit integers and collected for each integer from 0 to 9. The numbers of deaths from traffic accidents and of emergency calls were treated similarly. The frequency of appearance of each single digit integer was assessed by Fisher exact test to determine if the observed frequencies differed from expected frequencies, which were considered equal from 0 to 9.

The number of OHCAs witnessed by bystanders was converted to a common logarithm (base 10). The log transformed values were plotted as a histogram and the normality of the distribution was assessed to determine if it followed a Gaussian distribution. A quantile-quantile (Q-Q) plot was used to assess whether these data had a near-normal distribution.

Skewness and kurtosis were also used to assess the distribution pattern. Skewness examines whether a distribution is symmetric: skewness < -1 or $> +1$ indicates a highly skewed distribution; -1 to -0.5 or $+0.5$ to $+1$ indicates moderate skewing; and -0.5 to $+0.5$ indicates that the distribution is approximately symmetric.[13] Kurtosis examines the shape of the tail of the distribution. In this article, we define the kurtosis of a normal distribution as zero. Then, if kurtosis is > 0, the tail is longer and flatter, and if kurtosis is < 0, the tail is shorter and thinner compared to a normal distribution.[14] The numbers of deaths from traffic accidents and emergency calls were also log transformed and treated similarly. The rate of bystander CPR and the 1-month survival rate were not log transformed and were used as the original numbers.

Relationships among pairs of these variables were assessed by Spearman correlation analysis. A Wilcoxon signed-rank test was used to evaluate paired values of the guessed number of deaths from traffic accidents and the guessed number of OHCAs. A p-value less than 0.05 was considered statistically significant. All statistical analyses including descriptive statistics were performed with SPSS (ver. 25, IBM Japan Ltd, Tokyo, Japan).

Results

Responses to all surveys were obtained from 558 of 698 students, giving a response rate of 80.0%, and the rates significantly increased annually ($P < 0.05$). The median age of the participating students was 23 years old each year and interquartile ranges were 2 or 3 depending on the year. The percentage of male students ranged from 55.6% to 69.0% by year, with no significant trend (Table 1). The number of missing values for each question is shown in eTable 2.

The guessed numbers from students clearly differed from the real statistics, except for the rate of CPR by bystanders in 2013. The number of OHCAs, rate of bystander CPR, and the number of emergency calls for ambulances were significantly smaller compared with real data ($P < 0.001$ except rate of bystander CPR in 2013). In contrast, the number of deaths from traffic accidents and the 1-month survival rate after OHCAs with cardiac etiology witnessed by a bystander were significantly larger ($P < 0.001$) (Table 2). There were annual trends in real statistics, except for the number of OHCAs. The guessed numbers of death from traffic accidents ($P < 0.001$) and the rate of bystander CPR also significantly decreased annually ($P < 0.05$). The direction of the trend matched between the guessed number and the real data only for the number of deaths from traffic accidents.

In the guessed numbers of OHCAs by students, the minimum each year ranged from 10 to 200 and the maximum ranged from 1,000,000 to 60,000,000. These tendencies were also found for the distributions of the guessed numbers of deaths from traffic accidents and of emergency calls for ambulances (Table 2).

In the frequency table of numbers of OHCAs, 0 was predominant, followed by 1 and 5, and the appearance of numbers from 0 to 9 was clearly biased ($P < 0.001$). Similar patterns were observed for the guessed numbers of deaths from traffic accidents and of emergency calls for ambulances (Table 3).

This result rationalizes the common log transformation of the numbers of OHCAs of cardiac cause, deaths from traffic accidents, and emergency calls for ambulances. The distribution of the transformed number of OHCAs of cardiac cause was plotted as a histogram (Fig. 1). The skewness and kurtosis of the distribution were 0.60 and 1.30, respectively. This value of skewness shows that the distribution was moderately skewed from a normal distribution, and the positive value shows that the distribution deviates to the right. The value of 1.30 for kurtosis suggests a tail that is longer and flatter compared to a normal distribution. A Q-Q plot showed that the distribution was close to normal, with deviation from the normal distribution line caused mainly by the large numbers (Fig. 2).

Similar near-normal distributions were obtained for log transformed numbers of deaths from traffic accidents (skewness: 0.55, kurtosis: 0.92) and of emergency calls for ambulances (skewness: 0.14, kurtosis: 0.60). These distributions are shown as histograms (e Figs. 1 and 2). A similar type of Q-Q plot to that for OHCA was obtained for the log transformed

Table 1
Number, age, and sex of medical students who participated in surveys.

Year	Number of participants			Age of participants		Sex of participants	
	All studentsN	ParticipantsN	Response rate%	Median(IQR)	MaxMin	Male	Female
2013	112	74	66.1	23(3)	3321	51	23
2014	112	102	91.1	23(3)	4021	65	36
2015	115	81	70.4	23(2)	4321	45	33
2016	120	103	85.8	23(3)	3321	70	32
2017	125	107	85.6	23(3)	4521	72	34
2018	114	91	80.0	23(3)	4421	59	30
Significancefor annual trend	P < 0.05			P = 0.700		P = 0.767	

Table 2
Comparison between real statistics and guessed numbers from students.

Items*	Death from traffic accidents (n)			
Year	Real statistics	Median of guessed number (IQR)	Max Min	Significance for real statistics vs median
2013	4438	15,000 (95,000)	5,000,000 100	P<0.001
2014	4388	10,000 (25,000)	10,000,000 100	P<0.001
2015	4113	10,000 (25,000)	3,000,000 200	P<0.001
2016	4117	20,000 (94,125)	3,000,000 1000	P<0.001
2017	3904	10,000 (46,000)	4,000,000 500	P<0.001
2018	3694	8,000 (11,750)	10,000,000 300	P<0.001
Significance for annual trend	P<0.05	P<0.001		

Items*	OHCA of cardiac origin (n)			
Year	Real statistics	Median of guessed number (IQR)	Max Min	Significance for real statistics vs median
2013	73,023	20,000 (95,000)	30,000,000 200	P<0.001
2014	73,397	5,000 (13,000)	50,000,000 10	P<0.001
2015	76,141	8,500 (39,500)	1,800,000 60	P<0.001
2016	73,697	10,000 (46,000)	1,000,000 150	P<0.001
2017	75,109	10,000 (120,000)	60,000,000 13	P<0.001
2018	78,302	6,000 (17,500)	10,000,000 100	P<0.001
Significance for annual trend	P=0.188	P=0.164		

Items*	Bystander CPR (%)			
Year	Real statistics	Median of guessed number (IQR)	Max Min	Significance for real statistics vs median
2013	51.5	50 (40)	90 1	P=0.160
2014	51.1	44 (41.3)	100 0.5	P<0.01
2015	54.2	40 (36)	90 3	P<0.01
2016	55.8	42.5 (30)	100 5	P<0.001
2017	56.1	40 (37)	90 5	P<0.001
2018	56.6	50 (38)	100 5	P<0.001
Significance for annual trend	P<0.05	P<0.05		

Items*	1-month survival (%)†			
Year	Real statistics	Median of guessed number (IQR)	Max Min	Significance for real statistics vs median
2013	11.5	50 (50)	90 1	P<0.001
2014	11.9	50 (40)	95 1	P<0.001
2015	12.2	50 (45)	95 5	P<0.001
2016	13.0	50 (40)	95 2	P<0.001
2017	13.3	50 (43)	90 1	P<0.001
2018	13.5	50 (38)	90 2	P<0.001
Significance for annual trend	P<0.01	P=0.118		

Items*	Emergency calls for ambulances (n)			
Year	Real statistics	Median of guessed number (IQR)	Max Min	Significance for real statistics vs median
2013	5,805,701	200,000 (970,000)	35,000,000 100	P<0.001
2014	5,918,939	100,000 (230,000)	30,000,000 500	P<0.001
2015	5,988,377	100,000 (970,000)	20,000,000 500	P<0.001
2016	6,058,190	300,000 (970,000)	20,000,000 40	P<0.001
2017	6,213,628	100,000 (490,000)	30,000,000 250	P<0.001
2018	6,345,517	100,000 (370,000)	30,000,000 0	P<0.001
Significance for annual trend	P<0.01	P=0.329		

*Questions for these items for students were listed starting from death from traffic accidents and asked in the order shown in this table.
†1-month survival from OHCA witnessed by bystanders

*Questions for these items for students were listed starting from death from traffic accidents and asked in the order shown in this table.
†1-month survival from OHCA witnessed by bystanders.

Table 3
Frequency of appearance of single digit integers in answers from students.

Item	Number										
	0	1	2	3	4	5	6	7	8	9	Significance
Deaths from traffic accidents	2054	230	70	70	47	136	14	5	14	1	P < 0.001
OHCAs[a]	1886	180	82	60	27	157	18	14	27	8	P < 0.001
Patients transferred by ambulance	2623	210	60	61	17	107	91	5	10	8	P < 0.001

[a] Out-of-hospital caridiac arrests with caridiac etiology.

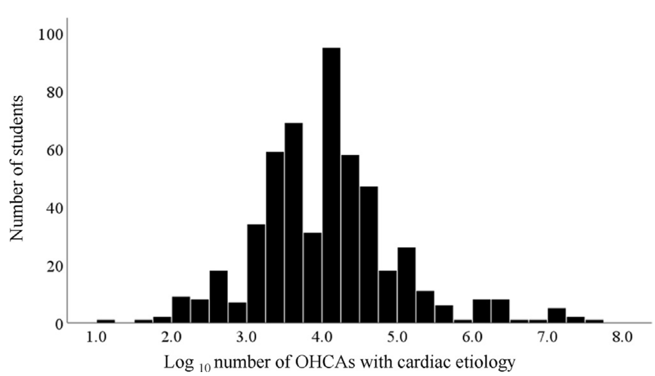

Fig. 1. A histogram showing the distribution of log transformed numbers of out-of-hospital arrests (OHCAs) guessed by students. The skewness and kurtosis of the distribution were 0.60 and 1.30, respectively. The absolute value of skewness of 0.60 suggests that the distribution was moderately skewed from a normal distribution. Since the value is positive, the distribution deviates to the right. The value of 1.30 for kurtosis suggests a tail that is longer and flatter compared to a normal distribution.

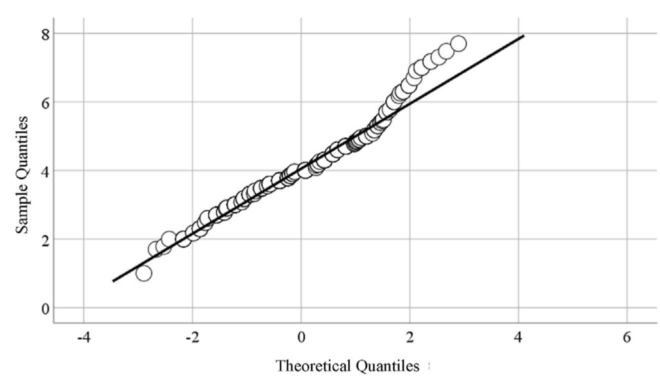

Fig. 2. Q-Q plot of log transformed numbers of out-of-hospital cardiac arrests (OHCAs). This Q-Q plot reflects a near normal distribution of the guessed numbers based on the plotted points being along the line for a normal distribution. The outlier points with large values are consistent with a long tail on the right side of the histogram and the values of skewness (0.60) and kurtosis (1.30).

numbers of deaths from traffic accidents (e Fig. 3). In the Q-Q plot of log transformed numbers of emergency calls for ambulances, outliers deviated opposite to the other two variables, reflecting the short tail of the histogram (e Fig. 4). The distributions for rate of bystander CPR (skewness: 0.10, kurtosis: 0.89) and 1-month survival from OHCA (skewness: 0.13, kurtosis: 1.12), which were not log transformed, are similarly shown in histograms (eFigs. 5 and 6) and Q-Q plots (e Figs. 7 and 8).

Among guessed numbers from students, positive relationships were found between deaths from traffic accidents and OHCAs ($P < 0.001$), between OHCAs and emergency calls for ambulances ($P < 0.001$), and between rate of CPR and one-month survival ($P < 0.001$) (e Table 3). The Spearman rank correlation coefficient was 0.48 for death from traffic accidents and OHCAs. Only 191 of 524 students (36.5%) guessed that OHCAs exceeded deaths from traffic accidents ($P < 0.001$), while 359 (66.5%) guesses exceeded the reported number of deaths from traffic accidents and simultaneously underestimated the reported number of OHCAs. Only two students (0.4%) overestimated the number of OHCAs use and simultaneously underestimated deaths from traffic accidents (Fig. 3).

Discussion

In our results, the guessed number by students were widely distributed. However it was not a meaningless chaos but some statistical pattern was recognized in the distribution. Analyses of the pattern of their answer suggests that students could estimate only digit numbers and that digit numbers except 0, 1 and 5 were not important to them. It was also suggested that the guessed digits by students followed normal distribution, but some values were outliers on the large side. Start point of our study was characterizing the pattern of the distribution in order to assess the perceptions of medical students. Our hypothesis is that assessing the perception of medical students relating to OHCA may identify potential problems in current resuscitation education.

Current resuscitation education for OHCA has focused on the general public as laypersons for treatment of OHCA victims. However, reconsideration of the educational effort for medical students is needed based on recent recognition of poor outcomes for CPR performance of final year students.[7,8] A medical student is a good candidate as a provider of comprehensive medical care, including resuscitation care, a key person for CPR decisions, and a leader in dissemination of resuscitation information in community health. For these reasons, medical students were targeted in the surveys in this study.

Another concern with resuscitation education is the educational content. Current resuscitation education focuses on technical and non-technical skills training. A statement from the American Heart Association addressed current educational strategies to improve direct skills for performance of resuscitation, such as mastery learning and deliberate practice, spaced practice, and contextual learning.[10] Medical students are one of the main targets as learners.[15–17] In addition to these strategies, it might also be important to cultivate medical students as potential leaders based on an understanding of the current resuscitation situation, such as frequency of OHCAs and real outcomes from resuscitation, in addition to theoretical CPR training. This is another reason for comparing guessed values from students with real statistics.

Two important results emerged from this study. First, the number of OHCAs was underestimated by medical students. The guessed number of OHCAs with cardiac etiology from the student was far lower than the real statistics, and even less than the guessed number of deaths from traffic accidents. In real statistics, the number of OHCAs is far larger than deaths from traffic accidents every year. This heuristic bias might be due to students being exposed to information on traffic accidents on the TV news or internet more frequently than OHCAs. While students can get the daily number of deaths from road traffic accidents in Japan on the internet every day,[18] they cannot get the daily number of OHCAs. In recent years, TV and newspapers report decreasing trend of the number of deaths from road traffic accidents when annual reports open. This

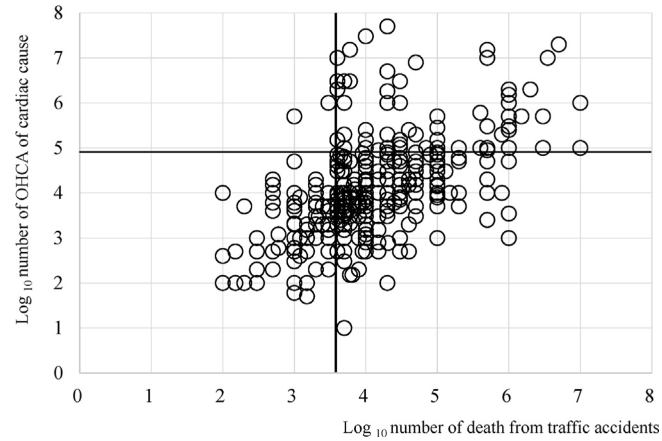

Fig. 3. A plot of log transformed numbers of out-of-hospital cardiac arrests (OHCAs) with cardiac etiology versus log transformed numbers of deaths from traffic accidents. The Spearman rank correlation coefficient was 0.48 for this plot. The vertical line in the graph shows the number of deaths from traffic accidents reported as real statistics. The horizontal line shows the number of OHCAs with cardiac etiology reported as real statistics. The distribution of 66.5% of the points in the lower right quadrant indicates that the frequency of OHCAs is underestimated compared to deaths from traffic accidents. There are only two points in the inverse (top left) quadrant.

might be related to our results of an identified directional trend in overestimation of road traffic deaths that matches the actual data. This comes from the heuristic bias of students who face difficulty judging elusive numbers.[19] The difficultly of the task is shown by how the students used the first digit, rather than a detailed number. This is related to the near-normal distribution of the log transformed values; that is, the results of judgment by the students are naturally distributed. The positive relationship of the log transformed guessed numbers of OHCAs with the log transformed guessed numbers of deaths from traffic accidents suggests a kind of phenomena of self-generated anchoring. Usually anchoring is called as a cognitive bias where an individual depends heavily on an initial piece of information offered outside when making decisions. Here the anchor is inside each students. The guessed number of OHCAs were influenced by the self-generated value of deaths from traffic accidents.

The second important result is that the guessed one-month survival rate from OHCAs for witnessed patients was far larger than the real statistics. We speculate that students answered roughly 50% on the answer sheet due to their difficulty with judgment. In general, students study fictional patients with OHCAs who are mostly successfully resuscitated if the students follow the CPR algorithm or if the patient does not have a do not resuscitate order. Thus, the student answers might not be attributed to their shortage of competence, but may reflect a problem in current resuscitation education, although this type of deliberate practice has been successfully introduced for students.[16]

One of the limitations of this study is the year the students completed the survey. We could not survey final year students, who might have been most appropriate to assess a final outcome of undergraduate education. However, the fourth-year students were motivated to learn basic life support because they were facing an objective structured clinical examination for certification as student doctors for clinical clerkship. Therefore, we believe that asking information on OHCAs makes sense in the fourth year.

In conclusion, OHCAs are underestimated in frequency, and survival after an OHCA is overestimated by medical students of fourth year, compared to real statistics. Resuscitation education programs may need to be revised with consideration of these heuristic biases in perceptions of medical students.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2020.100023.

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