cupy a separate family of its own. The karyotype of *Callimico* is intermediate between the marmoset karyotype and that of the cebid genus *Callicebus*. It can only be said that in this case the chromosomal evidence is in agreement with the idea, expressed by Hill (*36*), that the Callithricidae are a specialized, rather than a primitive group, and that *Callimico* is more primitive (and unspecialized) and is hence probably closer to the ancestral cebid stem.

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Human Behavior during the Tsunami of May 1960

Research on the Hawaiian disaster explores the consequences of an ambiguous warning system.

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At 1:05 HST on the morning of 23 May 1960, a great sea wave, or tsunami, caused by an earthquake off the coast of Chile (*1*), hit the Hawaiian city of Hilo. Despite at least 10 hours of warning, the wave killed 61 persons, injured several hundred more, and completely destroyed an estimated 500 dwellings.

A study group was organized by the Hawaii Division of the Hawaiian Academy of Science to objectively examine the human element in the disaster (*2*). The objectives of the research, subsequently undertaken, were to study the subjective interpretations of the warnings and the resulting behavior.

A questionnaire was prepared, to be administered to a cross section of the adult population of the affected areas. The questionnaire was designed on the basis of preliminary observations conducted in the devastated area and of impressions recorded prior to the impact. Pre-testing of the survey instrument was precluded by limitations of time and resources. The prepared questionnaire was explained to the interviewers in an item-by-item discussion of the intent of each question.

Many of the interviewers were close acquaintances of the individuals they were to interview. Hence, open and frank discussions could be initiated almost at once. Also, since the majority of affected families had not evacuated, failure to evacuate carried no social stigma. There is reason to believe, therefore, that the responses made by the people interviewed give a truthful picture of their impressions of the events.

A large number of those interviewed were at the Red Cross disaster shelter. This group formed a readily available starting point for interviews and also provided leads for locating other displaced individuals. Various church organizations made available the new addresses of their displaced congregations. The Department of Public Instruction required students in displaced families to report their new addresses. Lists of victims were thus compiled, and those to be interviewed were selected in a nonsystematic fashion. The interviewing was conducted over a period of seven successive days.

Representativeness of the Sample

The conditions under which the survey was made precluded our drawing a pure random or stratified random sample. No one possessed an exhaustive list of tsunami victims. Neither did we have valid information on the geographic distribution, or other relevant characteristics, of our population before the impact. We therefore sought to achieve, through the means described above, a "quasi-random" sample that

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Table 1. Composition of sample.

Sex	Age	Race	Education	Total sample		Nonevacuees		Evacuees	
				N	%	*N*	%	*N*	%
Male				140	42.8	88	44.7	52	40.0
Female				187	57.2	109	55.3	78	60.0
	18–27			59	18.0	29	14.7	30	23.1
	28–37			76	23.2	41	20.8	35	26.9
	38–47			77	23.5	45	22.8	32	24.6
	48–57			64	19.6	45	22.8	19	14.6
	58–67			33	10.1	25	12.7	8	6.2
	68 or older			18	5.5	12	6.1	6	4.6
		Caucasian		8	2.4	3	1.5	5	3.8
		Filipino		33	10.1	23	11.7	10	7.7
		Hawaiian		74	22.6	23	11.7	51	39.2
		Japanese		178	54.4	123	62.4	55	42.3
		Portuguese		15	4.6	14	7.1	1	0.8
		Other		19	5.7	11	5.5	8	6.1
			Grade or intermediate school	151	46.2	100	50.8	51	39.1
			High school	152	46.4	81	41.1	71	54.6
			College	24	7.3	16	8.1	8	6.2

is fairly representative of the population. We can, at the very least, assert that there was no artificial factor operating in the selection of our sample.

One factor lends support to our belief that findings in our sample of 327 can safely be generalized to the immediate parent population. The Red Cross records 500 families who registered or applied for assistance. This allows us to estimate the size of the total affected *adult* population at something between 1000 and 1200. Our sample of 327, then, represents between one-fourth and one-third of the entire adult population displaced by the tsunami. Samples of this order of relative magnitude, in the selection of which no artificial factors are involved, can, in general, be regarded as sufficiently representative to enable investigators to draw valid conclusions for the immediate parent population.

To evaluate the generalizability of our findings to future populations in Hawaii or to populations of disaster victims in the United States as a whole, cross validation through subsequent studies would be necessary, no matter how adequate a random sample we had been able to select from the target population.

In presenting the findings of our survey, we give, first, a description of various characteristics of the total sample. This is followed by the survey data, presented in the chronological order of the disaster events: pre-impact period, impact period, and post-impact period. Findings for the pre-impact period are divided into data on response to the siren signal and data in response to other warnings. We conclude with a consideration of the possible determinants of adaptive behavior during the emergency.

Characteristics of the Sample

The composition of our sample of 327 individuals in terms of sex, age, race, and education is summarized in Table 1. Our sample included 28 persons who had lost one or more members of their immediate family in the disaster. Also, 50 persons in the sample (15 percent of those interviewed) had themselves suffered injuries. Of these 50 people, 47 had not left their homes; the three injured among the evacuees either (i) left but later returned to their homes or (ii) sought safety in an area which was itself stricken.

Pre-Impact Period

The siren signal. The tidal-wave warning siren sounded for a 20-minute period more than four hours prior to the impact of the wave, yet only 40 percent of our sample evacuated, and presumably this was the percentage of the entire population of the devastated areas that evacuated. Therefore, the question was posed, "Did you hear the 8:30 siren on Sunday, May 22?" Of those interviewed, 309 (95 percent) replied that they had heard the siren; 18 (5 percent) replied that they had not. Of those who heard the siren, 127 (41 percent) evacuated and 182 (59 percent) did not.

The 309 individuals who had heard the siren were further asked if they knew what it meant. Only 18 individuals (6 percent) said they did not. However, in the course of analyzing our data it became obvious that not all of the 291 persons who said they knew what the siren meant had the same understanding of its significance. More revealing than the "yes" or "no" reply to this question, therefore, were the answers to the next two questions ("What did you do upon hearing the siren, and why?"), from which we could (in most cases) infer what the siren meant to each individual. In addition, unsolicited comments as to the meaning of the siren were frequently available. In Table 2 are summarized the various meanings the siren had for the 291 individuals who heard it.

Since the siren meant so many different things to different people, we began to wonder just what it was meant to signify officially. Consulting the telephone directory, which is presumably the official medium for disseminating this information, we found that the siren signal was characterized as an "alert," with no indication as to what behavioral response was expected of the public upon hearing it. It is significant that, of the 84 persons who we infer took the siren to mean an "evacuation signal," 74 (88 percent) did indeed evacuate their homes—if not right away, at least prior to the impact of the wave.

The distribution of responses to the

Table 2. Various meanings of the siren for the individuals interviewed who heard it.

Interpretation	Total sample		Nonevacuees		Evacuees	
	N	%	*N*	%	*N*	%
Alert	14	4.8	10	5.9	4	3.3
Warning	13	4.5	8	4.7	5	4.1
Preliminary signal preceding evacuation signal	71	24.4	55	32.4	16	13.2
Evacuation signal	84	28.9	10	5.9	74	61.2
Signal to await further information	26	8.9	24	14.1	2	1.7
Signal to make preparations	18	6.2	12	7.1	6	5.0
Subjective meaning not ascertainable	65	22.3	51	30.0	14	11.6
Total	291	100.0	170	100.1	121	100.1

siren is shown in Table 3. The disaster victims are classified according to their immediate response to the siren—according to whether they continued their normal routine, evacuated, or waited for information and instructions.

The "do-nothing" group consisted of 44 individuals who disregarded the siren signal and continued their normal routine. Most of these individuals (29, or 66 percent) stated that they believed themselves to be in a safe area. The remaining individuals in this group were either in the movies, disabled or aged, or reportedly "too tired" to respond. This do-nothing group is likely to be less responsive to remedial measures than the other groups.

Compulsory evacuation might be appropriate for the small minority of individuals represented by the 15 percent of our entire sample who did nothing upon hearing the siren because they were foolishly convinced that they were in no danger. However, individuals who wanted to could easily take evasive action. Perhaps the only feasible course is to vigorously prevent such individuals from congregating in dangerous areas for purposes of "sightseeing."

The group of 94 individuals who evacuated upon hearing the siren (32 percent of the 294 who reported their response) presents little or no problem. A desire for safety, awareness of danger, and fear are cited most often as the reasons for immediate evacuation. The individuals who "play it safe" are likely to do so consistently.

A detailed analysis of the large group of 131 people (44.5 percent of the 294) who indicated that they "waited" upon hearing the siren yields interesting conclusions. In answer to the question, "What did you wait for?," by far the largest number of people (60, or 46 percent) indicated that they waited for "another or final siren signal." Thirty-five people did not answer this question; the remainder of this group said they waited for additional information from radio or television, for aid in evacuating, or for "official notification" of the evacuation order.

The next question asked was, "Why did you wait?" Among the 104 individuals who answered this question coherently, the predominant response was that they felt they were, for the time being, in a safe area; 36 replied to that effect. The second most frequent response, made by 20 persons, was that they thought a final signal would be sounded when the impact of the wave was imminent. Other individuals waited to be sure that a wave was actually coming, or waited to receive more definite information.

Table 3. The relationship between ultimate evacuation and the immediate response to the siren.

Immediate response	Total sample		Nonevacuees		Evacuees	
	N	%	*N*	%	*N*	%
Did nothing (continued normal routine)	44	15.0	40	23.3	4	3.3
Evacuated	94	32.0	12	7.0*	82	67.2
Waited (for advice, information, etc.)	131	44.5	100	58.1	31	25.4
Other (returned home, etc.)	25	8.5	20	11.6	5	4.1
Total	294	100.0	172	100.0	122	100.0

*Represents individuals who evacuated upon hearing the siren but returned home prior to time of impact.

We may reasonably hypothesize that the bulk of the parent population falls into the "wait-and-see" group. The 95-percent confidence interval for the relative size of this group extends between 39 and 50 percent (*3*). It is concluded, therefore, that no less than 39 percent, and as high a proportion as 50 percent, of the local population might be expected to "wait" upon hearing a similar disaster warning. Most of the wait-and-see group in our sample made preparations for evacuation as they waited (in vain) for further instructions. Disaster-control agencies should seriously consider the possibility that current warning systems in other communities may produce similar wait-and-see responses.

The three-way classification of victims by their response to the siren may provide an interesting starting point for further research. Independent support of this trichotomy in investigations of personality and reinforcement history would be of both practical and theoretical significance.

Other warnings. To the question, "Did you have information about the wave before it hit, other than the siren?," 66 individuals (20 percent) responded in the negative and 261 (80 percent) in the affirmative. Table 4 summarizes the information sources cited by these 261. Eighty percent of the group (206) said they were listening to radio or watching television.

To the question, "What information did you receive?," 50 (19 percent) did not respond, 159 (61 percent) reported hearing that a tidal wave might have been generated and might be on its way, 22 (8 percent) had heard reports of its arrival in Tahiti, 15 (6 percent) reported hearing of flooding at the Hilo waterfront, hearing that the wave had passed Hilo, or hearing unclear reports. Fifteen individuals (6 percent) reported hearing that an evacuation had been ordered.

Next the 261 individuals were asked why they did or did not take action after hearing the various communications. At least 20 classes of replies were elicited. It seems clear that the communications were ambiguous with respect to the degree of danger and the proper response to the emergency. It appears that each person interviewed was forced to interpret for himself the communications he received, and that these communications were received primarily from radio and television.

Impact Period

Those interviewed were asked, "Where were you when the big wave hit?" Eighty-five of the people responding (43 percent of those who did not evacuate) said they had been at home asleep; 95 persons (48 percent of those who did not evacuate) had been at home awake.

Our analysis here is limited to the victims that did not evacuate. No significant differences in level of education were found between those who were at home sleeping and those who were at home awake (*4*). Why, then, did such a large number of individuals go to bed after an alert had been sounded? Twenty-six (31 percent) of those who were sleeping at the time of

Table 4. Source of information concerning the tidal wave, other than the siren.

Source of information	Individuals reporting	
	N	%
Relatives–friends	45	17.2
Radio–TV	178	68.2
Government (police, firemen, civil defense)	8	3.1
Radio–TV and relatives–friends	22	8.4
Radio–TV and government	6	2.3
Relatives–friends and government	1	0.4
No answer	1	0.4
Total	261	100.0

impact stated that they did nothing when the siren sounded, while only 11 (12 percent) of those who were awake at the time of impact reported that they did nothing on hearing the siren. Almost one-third of those who were sleeping belonged to the do-nothing group of individuals oblivious to the siren warning and convinced of their safety.

In comparing those who were asleep and those who were awake at the time of impact, another suggestive fact emerges. Upon being questioned about the siren, 30 (35 percent) of those who were asleep and 61 (64 percent) of those who were awake at 1:05 A.M. stated that they responded to the siren by waiting. Thus, most of the individuals who waited stayed awake during the period of waiting. This suggests that they interpreted the situation as serious, enough so to warrant staying awake to a relatively very late hour for inhabitants of Hilo. It is during this period of waiting that large numbers of individuals might have been persuaded to evacuate had there been coordinated and unambiguous directions over radio and television and a door-to-door warning by the police.

Fourteen individuals (4.3 percent of the total sample) reported that they were at the shore line at the time of impact, waiting to see the wave.

Post-Impact Period

Among the group of 197 people in the sample who did not evacuate, 112 (57 percent) were trapped in wreckage and 47 (23 percent) were injured. These figures point up the necessity of complete evacuation during a tsunami warning. Public communications during a tsunami alert should emphasize the fact that if a large wave should strike, then over half the people remaining in the danger areas will be buried in wreckage and one-quarter will be injured or killed. This is a straightforward statistical inference drawn from the data given above (*5*).

Six of the individuals who were trapped in wreckage and three who were injured were people who had returned after leaving their homes, or people who had evacuated to an area that suffered damage. Specification of danger zones in the pre-impact period is mandatory.

Table 5 shows who rescued the 118 individuals of our sample who were caught in wreckage. It should be noted that the figures for the firemen, police, and civil defense category and for the "strangers" category may be inaccurate. Because of a power failure at the time of impact, there was almost total darkness (*6*), and no illumination equipment was available during rescue operations. Presumably, victims recognized friends or relatives among the rescuers by their voices.

Sixty-five percent of the people who got out by themselves did so within the first hour after the impact. A sustained and organized rescue effort is a reasonable requirement in such an emergency; in the Hilo disaster, most of those who did not free themselves in the first hour after the impact required help (*7*).

Possible Determinants of Adaptive Behavior

One of the first things that comes to mind in studying the factors associated with adaptive behavior in emergency situations is amount of education. We studied this variable in two connections

A Hilo shopkeeper talks with an interviewer at the site of his store, which was destroyed by the tidal wave.

Table 5. Response to the question, "Who dug you out of the wreckage?"

Response	Individuals reporting	
	N	%
Got out alone	48	40.7
Family or friends	26	22.0
Strangers	9	7.6
Firemen, police, or civil defense	28	23.7
Did not know	5	4.2
No answer	2	1.7
Total	118	99.9

in our investigation of the Hilo disaster.

First, we compared the average amount of education of those who evacuated and of those who did not and found the figures to be 9.2 and 10.1 years, respectively. The difference is too small to be of any practical consequence. Statistically speaking the difference is significant at the 5-percent level (critical ratio, 2.14). Nevertheless, we feel justified in discounting amount of education as a determining factor, because surely it cannot be claimed that a mere 0.9 year of extra formal schooling for evacuees as against nonevacuees accounted for the difference in behavior.

Secondly, we compared the average amount of education of the nonevacuees who were asleep at time of impact with the amount of those who were awake. Those who were asleep had slightly more education, but the difference was not significant (*4*).

Table 1 shows that of the 151 individuals with intermediate or grade-school training, 51 (33 percent) evacuated and 100 (66 percent) did not. Among the 24 victims with varying amounts of college training, 8 (33 percent) evacuated, while 16 (66 percent) did not.

Thus, we have evidence to support the conclusion that formal education is not a determinant of whether or not an individual shows adaptive behavior in the form of evacuating or staying awake during an emergency situation.

Members of the sample were asked, "Have you been through anything like this disaster before?" Four of those interviewed did not respond, 117 (59 percent) of those who did not evacuate and 67 (51 percent) of those who did answered "No"; 77 (39 percent) of those who did not evacuate and 62 (48 percent) of those who did answered "Yes." For individuals who had had previous disaster experience, the difference in the percentages of those who evacuated and of those who did not was 9 percent. This difference yields a critical ratio of 1.61 with a probability of 5.4 percent for a one-tail test. We conclude, therefore, that disaster experience increases the probability of adaptive behavior in subsequent emergencies. However, this increase is only of the order of 9 percent in our sample.

Table 1 gives figures for the various ethnic groups and shows that 69 percent of the Hawaiian members of the sample evacuated. An elaborate mythology exists pertaining to Hawaiian deities and geophysical events (*8*). Perhaps we have here an instance where such beliefs resulted in adaptive reactions.

Our findings have ruled out education and have relegated previous disaster experience to a minor role as a determinant of adaptive behavior in response to ambiguous emergency warnings. Personality factors, such as chronic anxiety, loom large as a possible explanation of the behavior recorded. These conclusions are, of course, subject to cross validation through further research.

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3. These figures are based on findings for 294 individuals who gave coherent answers to the question concerning their behavior after hearing the siren signal. The 95-percent confidence limits were computed without a finite multiplier.
4. A comparison of the average amount of education of those nonevacuees who were asleep and of those who were awake at the time of impact yielded averages of 9.4 and 9.0 years, respectively. The difference is far from being significant at the 5-percent level (critical ratio, <1).
5. The appropriateness of our recommendation concerning public communications during a tsunami alert is substantiated by the calculation of confidence limits for the proportions of victims who were trapped inside wreckage and of those who were injured, among the nonevacuees. The 95-percent confidence interval extends from 50.1 to 63.9 percent for the proportion trapped inside wreckage—figures which justify our saying "over half." The corresponding confidence interval for the proportion of injured among the nonevacuees extends from 17.1 to 28.9 percent, showing that "one-quarter" is a reasonable estimate.
6. The moon was new during this period of May 1960; thus, visibility without artificial illumination was extremely limited.
7. The Hilo Civil Defense Log contained the following entry dated 23 May 1960, 0325 hours: "From Hilo Civil Defense to Central Police Communications Center, 'No one to enter area till daylite [sic].'"

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