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Author(s)	Murata, Tadahiko; Fukushima, Atsuki; Harada, Takuya et al.
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Social Awareness from Analysis of Available Time for Automated External Defibrillators in a City

Tadahiko Murata Atsuki Fukushima
Faculty of Informatics
Kansai University
Takatsuki, Osaka
murata@kansai-u.ac.jp

Takuya Harada
College of Science & Engineering
Aoyama Gakuin University
Sagamihara, Japan
harada@ise.aoyama.ac.jp

Mie Sasaki
Graduate School of Medicine
The University of Tokyo
Bunkyo, Tokyo

Abstract—In this paper, we conduct an investigation of available time for automated external defibrillators (AED) in a Japanese city. In Japan, there are about 600,000 AEDs available in cities or towns, but only 4.9% of AEDs are used by bystanders when citizens suffer a sudden cardiac arrest. One reason of such low usage rate comes from their available time. Since many AEDs are installed by business owners, they are not available when their business is closed. We investigate the available time of AEDs in a Japanese city, Takatsuki, Osaka Japan. The number of AEDs that are available 24 hours can be increased by installing new AEDs in 24-hour convenience stores and a koban that is a small police station with policemen.

Keywords—Automated External Defibrillators, Available Time,

I. INTRODUCTION

In Japan, about 80,000 cardiac arrests happened [1]. Among them, about 20,000 to 25,000 patients are witnessed by bystanders. According to the All-Japan Utstein Registry maintained by the Fire and Disaster Management Agency (FDMA) in Japan [1], 1-month survival rate after Out-of-hospital cardiac arrest (OHCA) without applying AED in 2018 was 11.8%. On the other hand, survival rate with applying AED was 55.9%. It is known that the survival rate will decrease 7-10% per minute after OHCA. It is very important to call for emergency medical service (EMS) and then apply AED to the patient as soon as possible. However, it is a little bit late for patients since the average arriving time of EMS (i.e., ambulance) in Japan was 8.7 minutes in 2018 [1]. In order to save their lives, it is essential to improve public access defibrillation (PAD) [2-4]. In order to apply AED in 5 minutes, an AED should be placed within 2 minutes distance from each home (It may take 2 minutes to recognize the necessity of AED, and 1 minute to apply AED to the patient). If a bystander can walk fast by 9 km/hour, it is 150m for a minute. When we can place AEDs in every 300m in the target place, it will be 150m at most from every home. Bystanders in a home can bring an AED in 2 minutes.

In Japan, lay bystanders can apply an AED to a patient of OHCA. However, it is only 4.9% (1,254) of all 25,756 OHCA witnessed by bystanders to apply AEDs to the patients. In the rest cases of 95.1% (24,502), AED was not applied to the patients. AEDs may be used by the following reasons: A) Bystanders hesitate to use AEDs, B) Bystanders do not know locations of AEDs, and C) Bystanders know the location of AEDs but they are not available.

In order to cope with the reason A, several organizations have training courses for potential bystanders to get used to apply AEDs to patients. For the reason B, several AED Maps are available as WEB pages or applications for smartphones. For example, Japan Emergency Medical Care Foundation develops “Foundation Japan AED Map” that has 336,724 AEDs (as of March 11, 2021), and Japan AED Map

Committee develops “Japan AED Map” that has 306,209 AEDs (as of March 11, 2021), and Japan AED Foundation develops “AED N@VI” that has 65,307 (as of March 11, 2021). Some prefectures or cities develop AED maps by themselves. In this paper, we approach the availability of AEDs in C. Although there are AEDs around the location of a patient of OHCA, some of them are not available since they are installed by business owners and their buildings are out of service in early morning or night.

When the buildings where AEDs are installed are out of service, bystanders are not able to bring an AED from those buildings. In order to see the availability of AEDs, some maps mentioned above have information about available time in their registration scheme.

In this paper, we employ Geographical Information System (GIS) tools for social awareness. The information system such as GIS can be an effective tool for making us aware of social needs. We investigate available time of AEDs in a Japanese city. We also employ Geographical Information System (GIS) to analyze the distance between AEDs. As we have mentioned in the above, AEDs are preferably installed within 300 m between them. We employ the location information registered in “Foundation Japan AED Map” and “Japan AED Map.” We analyze the number of AEDs and their available time. After the analysis of the available time of AEDs, we propose a scheme to increase the number of AEDs that are available for 24 hours and show its effectiveness with regard to the distance between AEDs.

II. ANALYSIS FOR THE AVAILABLE TIME OF AEDS

In this paper, we analyze the available time of AEDs in Takatsuki city, Osaka Prefecture, Japan. Takatsuki city has a population of 351,082 in December 2020. Fig. 1 shows the map of Takatsuki city. The city locates between Osaka and Kyoto and it is one of satellite cities that delivers its residents as workers or students to other major cities. In Takatsuki, there are two railways that are West Japan Railway (JR) and Hankyu Railway. West Japan Railway gives a network called “Tokaido Line” that connects from Tokyo to Kobe in Hyogo Prefecture. From JR Takatsuki station, it takes 41 min to Sannomiya station (Downtown Kobe), 19 min to Osaka station, and 12 min to Kyoto station. Hankyu Railway also gives a network between Kyoto, Osaka and Kobe. It takes 57 min to Kobe-sannomiya station (the station next to JR Sannomiya station), 25 min to Osaka Umeda station (the station next to JR Osaka station), and 28 min to Kyoto Kawaramachi station (no direct network between JR Kyoto and Kyoto Kawaramachi station). Takatsuki city has two JR stations (Takatsuki and Settsutonda) and three Hankyu stations (Takatsuki-shi, Kammaki, and Tonda). Downtown Takatsuki locates between JR Takatsuki station and Hankyu Takatsuki-shi station. Although the northern part of Takatsuki

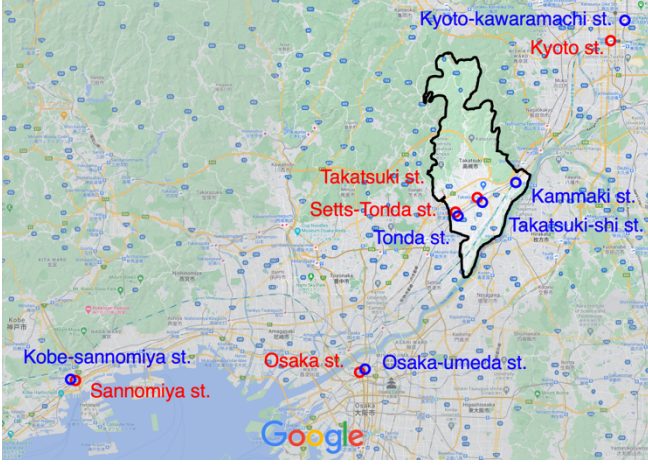


Fig. 1. Takatsuki-city between Osaka and Kyoto (Google Map).

city is mountain areas, there are several shopping areas around stations. Residential areas spread between railways and Yodo River flows in the southern boundary between Hirakata city.

As of January 23, 2021, there are 523 AEDs in Takatsuki city that are registered in “Foundation Japan AED Map” and 459 in “Japan AED Map.” Excepting AEDs registered in both maps, we analyze 680 AEDs in Takatsuki city. We investigate the available time using the information on the webpages of the business owners whose shops have their AEDs. We consider AEDs are available when customers can visit the shop. Even if some employees are working in the shop, we consider AEDs are not available when the shop is closed. In this study, we do not consider regular holidays for each shop.

For AEDs installed in stations and banks, we set the different available time according to the location in the station or bank. For AEDs installed in the platform, they are available from the first train to the last train. However, the AEDs installed in the station manager’s office, we set the available time 1 hour before the first train and 1 hour after the last train.

For AEDs installed in banks, we set the different available time AEDs installed in tellers’ areas or ATM areas. In tellers’ area, AEDs are available only within the opening hour of tellers. However, we set the available time for AEDs in ATM areas depending on the opening hours of the ATM areas.

For AEDs in other facilities that we cannot find the available service time, we set it as follows: AEDs in nursery schools, kindergarten, and elementary schools, we set the available time from 7:30 to 19:00. AEDs in junior high schools and high schools, we set the available time from 7:00 to 21:00. For AEDs in temples or shrines, we set they are available 24 hours since priests may reside in the site. If the business hours are not shown in the webpage, we assume their business hours from 9:00 to 18:00.

III. SURVEY RESULTS

A. Distribution of AEDs in Takatsuki City

Fig. 2 shows a map of distributions of all 680 AEDs in Takatsuki city. We can see that a lot of AEDs are distributed in downtown area of the city near to the five stations in the city. Using the latitude and longitude of each AED, we

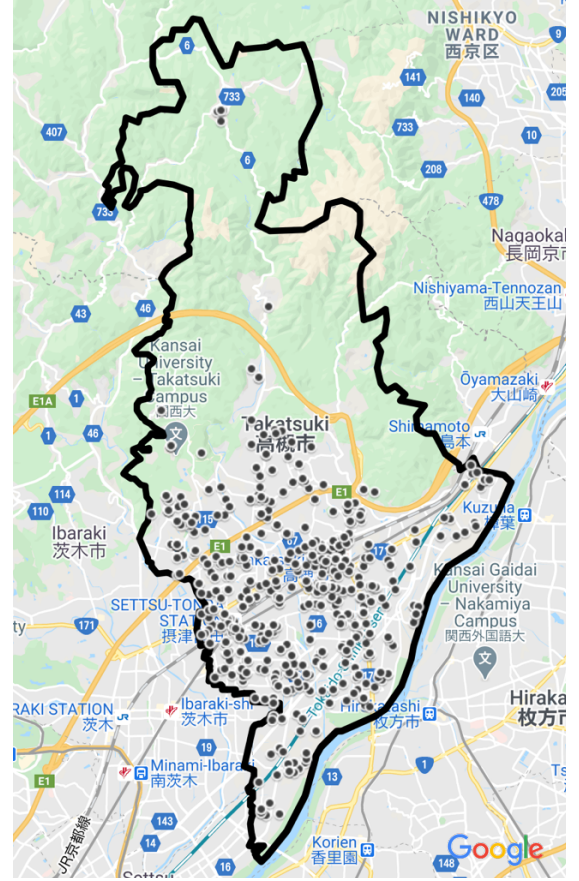


Fig. 2. Distributions of AEDs in a weekday in Takatsuki City (680 AEDs).

TABLE I The mutual distance of AEDs installed in Takatsuki city.

Distance	
Min.	0 m
Max.	1,631 m
Average distance over 680 AEDs	75.3 m
Average distance over 540 places	121.4 m

calculate the distance in a straight line between an AED and its nearest AED. TABLE I shows the minimum and maximum distance between two AEDs and their average distance. From TABLE I, we can see that the minimum distance is zero. This means that several AEDs are placed in the same building (the same address). TABLE II shows the number of places with multiple AEDs. From this table, we can see that AEDs are installed in 540 different places in Takatsuki city. We have not yet confirmed the distance among AEDs in the same building. It remains as further studies. The most distant AED from another AED locates near to the highway (E1A in Fig. 2). As shown in TABLE I, the average minimum distance between AEDs (including AEDs in the same buildings) is 75.3m. When we calculate the average distance between different places, it is 121.4 m.

We counted the number of AEDs in the same distance (that is, they are installed in the same building). The result is shown in TABLE II. There are 470 places with a single AED, and there is one place that has 18 AEDs. We have counted the number of AEDs within a specified distance in TABLE III. We can see that there are 210 AEDs that locates in the same building with multiple AEDs. TABLE III shows 88 AEDs locates within 5 meters from another AED. These AEDs may

TABLE II The number of AEDs within a specified distance.

# AEDs	1	2	3	4	5	11	18	Total
# Places	470	46	10	7	4	2	1	540

TABLE III The number of AEDs within a specified distance.

Distance	No. of AEDs	Proportion in All AEDs
0 m	210	30.9%
5m >	298	43.8%
10 m >	313	46.0%
20 m >	332	48.8%
50 m >	400	58.8%
100 m >	495	72.8%
150 m >	558	82.1%

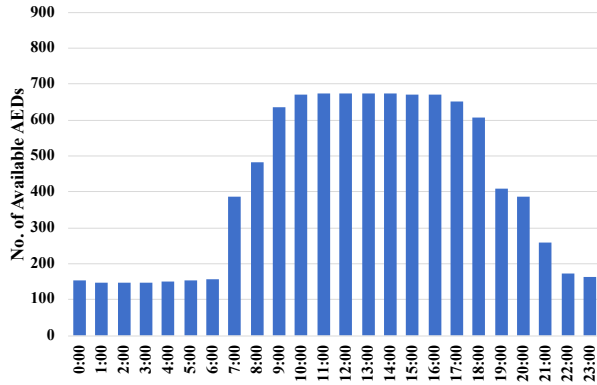


Fig. 3. The number of available AEDs in each hour in weekday.

TABLE IV The number and the proportion of available AEDs in weekday

Hour	Available AEDs	Proportion in All AEDs
0:00	153	22.5%
1:00	148	21.8%
2:00	147	21.6%
3:00	147	21.6%
4:00	149	21.9%
5:00	155	22.8%
6:00	157	23.1%
7:00	388	57.1%
8:00	481	70.7%
9:00	636	93.5%
10:00	672	98.8%
11:00	675	99.3%
12:00	674	99.1%
13:00	673	99.0%
14:00	673	99.0%
15:00	672	98.8%
16:00	671	98.7%
17:00	651	95.7%
18:00	606	89.1%
19:00	410	60.3%
20:00	387	56.9%
21:00	258	37.9%
22:00	174	25.6%
23:00	162	23.8%

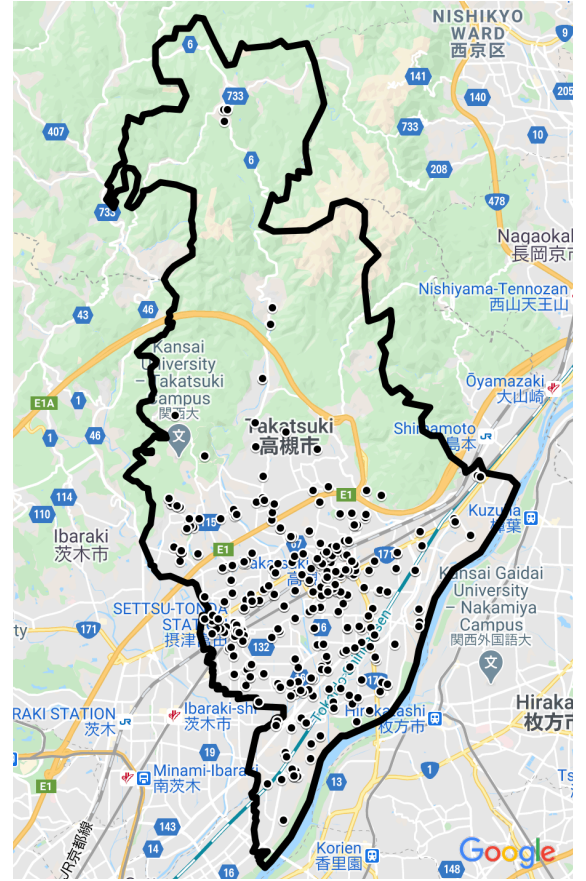


Fig. 4. Distributions of AEDs in a weekend in Takatsuki City (383 AEDs).

also locate in the same building but the different places according to their latitude and longitude information. TABLE III also shows that 82.1% of all AEDs in Takatsuki city locates within 150 m from another AED. We can see that citizens residing in AED concentrated areas can reach to AEDs within 5 minutes if they are available.

B. Available Time of AEDs in a Weekday

We count the number of available AEDs in a specific hour in a day. For example, an AED that is available from 7:30, we count that AED in 7:00. Fig. 3 shows the number of available AEDs in each hour in a day based on TABLE IV. TABLE IV shows that 100% of AEDs are not available in any hours. We have the largest number of available AEDs in 11:00AM. Since there are clinics that open only in the afternoon, and public baths that open from 16:00. We have the smallest number of available AEDs in 2:00 or 3:00 in the midnight. In these hours, only 21.6% of all AEDs are available. We can see a significant decrease from 22:00 to 6:00. This significant decrease should be approached by some means.

The increase from 7:00 comes from 112 AEDs of nursery schools, kindergarten, elementary schools, junior high schools, high schools and universities. The increase from 9:00 comes from AEDs that locates in business offices, banks and supermarkets. In 19:00, the many AEDs becomes unavailable since schools are closed and many business offices and clinics are closed.

C. Available Time of AEDs in Weekend or Holiday

Fig. 4 shows the distribution of AEDs in weekend or holidays. Fig. 5 and TABLE V show the number of AEDs in

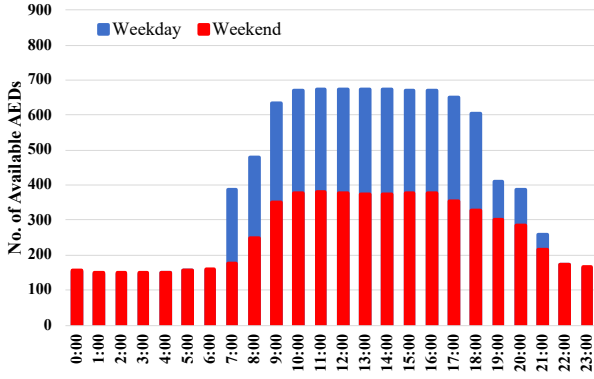


Fig. 5. The number of available AEDs in each hour in weekend.

TABLE V The number and the proportion of available AEDs in Weekend

Hour	Available AEDs	Proportion in All AEDs
0:00	155	22.8%
1:00	150	22.1%
2:00	149	21.9%
3:00	149	21.9%
4:00	151	22.2%
5:00	157	23.1%
6:00	159	23.4%
7:00	175	25.7%
8:00	249	36.6%
9:00	350	36.8%
10:00	378	55.6%
11:00	380	55.9%
12:00	379	55.7%
13:00	375	55.1%
14:00	375	55.1%
15:00	377	55.4%
16:00	377	55.4%
17:00	354	52.1%
18:00	329	48.4%
19:00	300	44.1%
20:00	284	41.8%
21:00	216	31.8%
22:00	173	25.4%
23:00	165	24.3%

weekend in each hour. In weekend or holidays, we do not count AEDs in clinics, nursery schools, kindergartens, elementary schools, junior high schools, high schools, and universities. Therefore, the number of available AEDs becomes 383 that is 56.3% among all AEDs. The number of AEDs in 0:00 becomes two more than that in a weekday because some amusement stores open longer than weekdays. Comparing Figs. 3 with 5, and TABLES IV with V, we can see that the number of AEDs during 22:00 to 6:00 does not differ so much. Therefore, we consider how to increase the number of AEDs during those hours.

D. AEDs that have 24 hour access

Fig. 6 shows the distribution of the 146 AEDs that are available for 24 hours. Compared to Figs. 2 and 4, remaining AEDs in Fig. 6 locate mainly along with West Japan Railways.

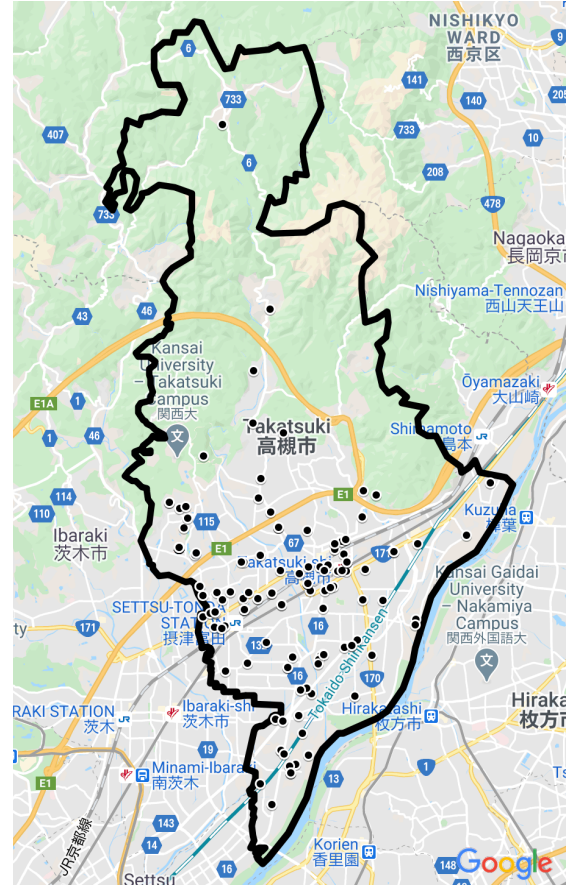


Fig. 6. AEDs that are available for 24 hours (146 AEDs).



Fig. 7. AEDs placed near to JR Takatsuki station and Hankyu Takatsuki-shi station (11:00).



Fig. 8. AEDs placed near to JR Takatsuki station and Hankyu Takatsuki-shi station (2:00).

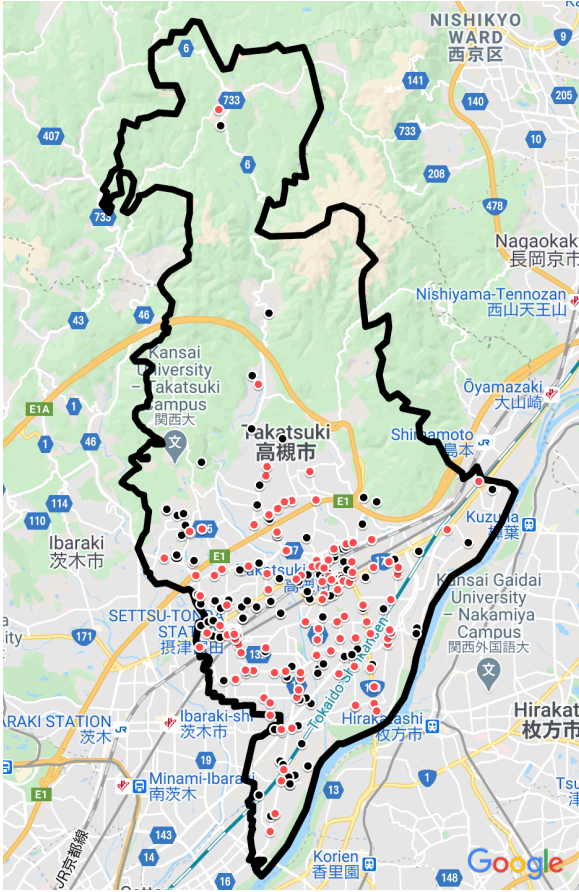


Fig. 9. AEDs that are available for 24 hours (146 AEDs) and candidate AEDs that are placed in convenience stores or police boxes (115 AEDs: red).

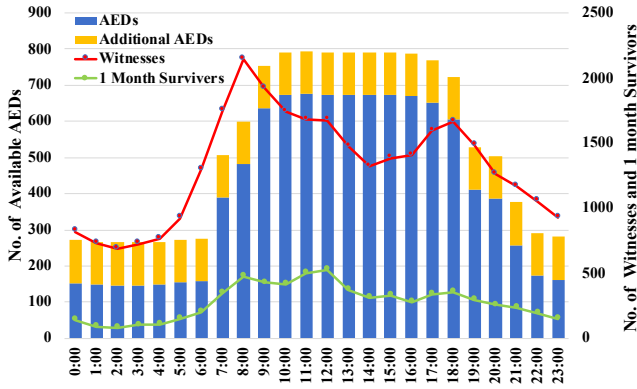


Fig. 10. The number of AEDs when AEDs are installed in convenience stores and police boxes (Left axis) and the number of witnesses and survivors after 1 month (Right axis).

TABLE VI The mutual distance of 24-hours AEDs.

	Distance
Average distance over 146 AEDs	373.8 m
Average distance over 261 AEDs	171.5 m

Those AEDs available for 24 hours locate in hospitals, fire stations or factories. Figs. 7 and 8 show the AEDs available in 11:00 and 2:00 in the downtown area of Takatsuki city, respectively. From these figures, we can see that the number of available AEDs decreases even in the downtown area. It is important to increase the number of AEDs that are available

for 24 hours even in the downtown area in the city.

After examining the registered AEDs in “Foundation Japan AED map” and “Japan AED Map,” we found that there are no AED installed in convenience stores or Koban, that is, police boxes. These facilities are open 24 hours in Takatsuki city, it is a good mean to place AEDs in those facilities. Fig. 9 shows the distribution of AEDs that are available for 24 hours when AEDs are added in convenience stores and police boxes (115 places in Takatsuki city). Since these facilities are placed near to residential areas, we can expect to improve the effectiveness of AEDs with these placements.

Fig. 10 shows that the number of AEDs after installing AEDs in convenience stores and police boxes in each hour. The figure also shows the number of witnesses of patients of OHCA and the number of survivors who can return to their community after 1 month based on the All-Japan Utstein Registry in 2017. From Fig. 8 we can see that the number of witnesses of OHCA patients increases in the morning (6:00-8:00) and in the early evening (17:00-19:00). This is because family members may find someone in their family had OHCA when they get up or come back home from school or workplaces. However, the number of survivors who can return to their community does not increase as the number of witnesses. It may be late for victims of OHCA. From this figure, we can learn that it is important to find patients of OHCA as soon as possible and bring the nearest AED to the patient to revive their heartbeat using the AED.

TABLE VI shows the mutual distance among 24-hour access AEDs. When we calculate the average distance among 146 AEDs, it was 373.8 AEDs. After installing 115 AEDs in convenience stores and police boxes, the mutual distance among AEDs can be half. We can see the effectiveness installing AEDs in convenience stores and police boxes.

IV. CONCLUSION

In this paper, we propose installation of additional AEDs in convenience stores and police boxes to increase the number of AEDs that are available for 24 hours. Our survey on time availability of AEDs shows that the number of AEDs significantly decrease in mid night. In order to improve the situation, it is a good means to place AEDs in these 24-hour facilities.

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