MSS | Disaster Prevention Plan | Stranded People

Collaboration Projects

"Mobile Spatial Statistics" Supporting Development of Society and Industry
—Population Estimation Technology Using Mobile Network Statistical Data and its Application—

Using Mobile Spatial Statistics in Field of Disaster Prevention Planning

The issue of people that could become stranded because of an earthquake directly below the Tokyo metropolitan area is being actively discussed. Information about population statistics is used in the pre-planning of measures to deal with stranded people, and it is expected that MSS can be used for this purpose. In this research, we estimated the number of people liable to become stranded in Tokyo in the event of an earthquake directly below the metropolitan area, and the number of citizens liable to become stranded while away from home. We also calculated the number of people returning home on foot after a disaster, and we verified the usefulness of MSS for such purposes. This research was conducted jointly with the Murakami Laboratory at the School of Architecture, Kogakuin University (Associate Professor Masahiro Murakami).

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1. Introduction

On March 11, 2011, the Tohoku earthquake and tsunami caused large numbers of people to become stranded in the Tokyo metropolitan area. Active discussions are now under way to address the issue of people that could become stranded due to the paralysis of public transport that would accompany an earthquake directly below the Tokyo metropolitan area. In July 2005, the cabinet office presented a thorough analysis of likely damages as compiled by the Central Disaster Prevention Council's expert committee on countermeasures against the Tokyo Inland Earthquake [1], and in October 2008 the basic policy for the safe return of stranded people was published by the expert committee on evacuation measures for the Tokyo Inland Earthquakes [2]. Similarly, from Tokyo, a May 2006 report "Estimated Damage Caused by Future Earthquakes Occurring beneath Tokyo" discussed the effects on stranded people [3]. Furthermore, as a busi-

ness model in Tokyo, committees have been established in collaboration with metropolitan districts by organizations such as businesses and schools near train stations, and these committees are looking at how to deal with people stranded at stations by such means as establishing regional action plans to mitigate the chaos expected near these stations after a disaster has occurred until full-scale public support becomes available. Recently, in the wake of the Tohoku earthquake and tsunami, the specific issue of dealing with stranded people has been pushed to the fore, including the establishment of a cabinet office and a committee on measures for stranded people in the event of an earthquake beneath Tokyo.

According to a 2006 estimate of damage suffered in Tokyo [3], an earthquake of intensity 5 or more occurring at 12 noon in the metropolitan area could cause the displacement of approximately 11.44 million people in the city, of whom approximately 3.92 million would end up being stranded[*1]. This estimate is based on a person trip survey[*2] performed on a weekday once every ten years [4], and has several issues including:

- None of the changes in urban structure or demographics that took place after the person-trip survey of 1998 are reflected.
- It is only possible to estimate the effects of disasters that occur at a particular time of day on a weekday.
- There is no consideration of factors such as sightseers from beyond the neighboring prefectures.
- There is a lack of information on specific genders or age groups that would help provide specific measures for dealing with stranded people, such as implementing a staggered re-homing system in cooperation with other regions, and supporting people requiring aid during a disaster.

In view of the above situation, we are studying the possibility of using Mobile Spatial Statistics (MSS) for the advance planning of measures to deal with stranded people. In this research, taking Tokyo as the field of verification, we have produced estimates of — among other things— the numbers of people that could become stranded in each metropolitan district in the event of an earthquake directly below the metropolitan area, and the number of people stranded while away from home. We also calculated the number of stranded people (including local residents) entering and passing through each metropolitan district as they return home on foot to homes in the neighborhood after a disaster. Compared with existing estimates, the estimated values obtained using MSS are characterized by freshness of data and temporal continuity that allows estimates to be made for different days of the week and different times of day, and it has been confirmed that they can be used in advance planning for stranded people. In this article, we demonstrate the usefulness of estimated results of this sort, and we report on the results of studying measures for dealing with stranded people, taking Shinjuku ward in Tokyo as a model case.

This research was conducted jointly with the Murakami Laboratory at Kogakuin University.

2. Analysis Using MSS

Hitherto, the cabinet office and Tokyo have produced damage estimates based on a person-trip survey performed in 1998, which provides population statistics limited to weekdays, so the published estimate results only relate to a specific time of day on weekdays. On the other hand, in this research we used MSS to produce separate estimates of the number of people stranded in each of Tokyo's metropolitan districts for disasters occurring on weekdays or at weekends, broken down by gender, age and the time of the disaster (in one-hour slots). In this research, we used MSS gathered over the period from December 1 though December 7, 2010.

2.1 Definition of the Number of Stranded People

In the context of a situation where public transport is unable to operate in the event of a disaster, a stranded per-

*1 New damage estimates for Tokyo were published in April 2012.
*2 **Person trip survey**: A questionnaire survey that studies the movements of people in a particular area.

son has various definitions including someone who wants to return home but is unable to do so, or someone who needs help or protection getting home. As basic information for the discussion of preliminary measures, estimation methods are generally used by the cabinet office and Tokyo [3][5], and we used the same definition in this research. Specifically, of the population left behind at the time of an earthquake (hereinafter referred to as "the number of affected people"), it is assumed that those living more than 20 km away will all become stranded, while those living less than 10 km away will all be able to return home. For individuals that live between 10 and 20 km away, the proportion that will become stranded is defined as increasing at a rate of 10% per km due to the effects of individual differences in physical strength, etc.

2.2 Calculation of the Number of People that Can Walk Home

Based on the estimated number of affected people, we calculated how many residents of Tokyo and its neighboring prefectures (for the purposes of this research, the neighboring prefectures are assumed to be Kanagawa, Saitama, Chiba and Ibaraki) walk back home across metropolitan districts. Specifically, the number of affected people in each metropolitan district is broken down by their areas of residence, and their journey home is modeled as the shortest path between the center of the area of the metropolitan district in which they are staying and the center of the metropolitan district in which they live, with a uniform walking speed of 4 km/h. In this research, we confined ourselves to eleven metropolitan districts situated along National Route 20 (Shinjuku, Shibuya, Suginami, Setagaya, Mitaka, Chofu, Fuchu, Kunitachi, Tachikawa, Hino and Hachioji).

3. Estimated Results and Their Usefulness

Figure 1 shows the number of people that would become stranded throughout the whole of Tokyo in the event of disasters happening at different times of day on weekdays and at weekends, as calculated using MSS. From the results of this analysis, the largest number of stranded people would be approximately 4.25 million for a disaster occurring at 3 pm on a weekday.

Figure 2 shows the distribution of the number of stranded people in this worst-case scenario, together with a breakdown of the figures. In addition to being able to produce estimates for disasters occurring at different times of day, it is also possible to perform separate calculations for people of different genders, age groups and areas of residence, and these results can be used to study things like the need for facilities where stranded people can stay temporarily. In particular, since it is possible to obtain estimated figures for people of different genders and age groups, and even for people arriving from beyond the neighboring prefectures, it can be expected to result in plans that are more concretely specified with regard to considerations of gender, support measures and so on.

Figure 3 shows where people from

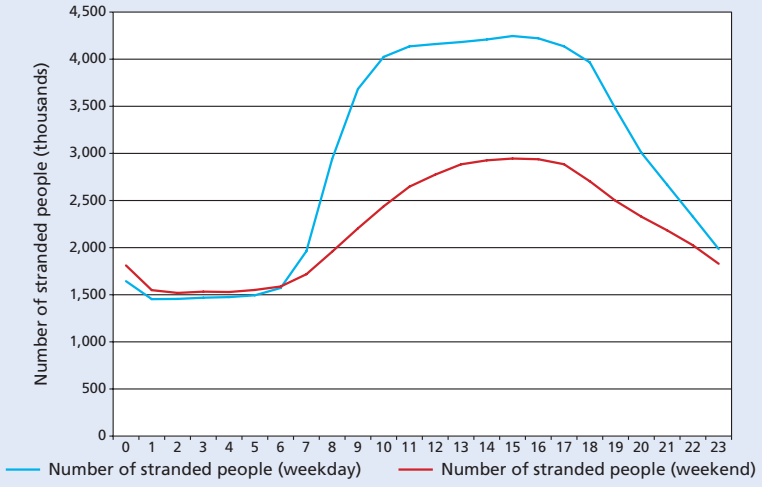
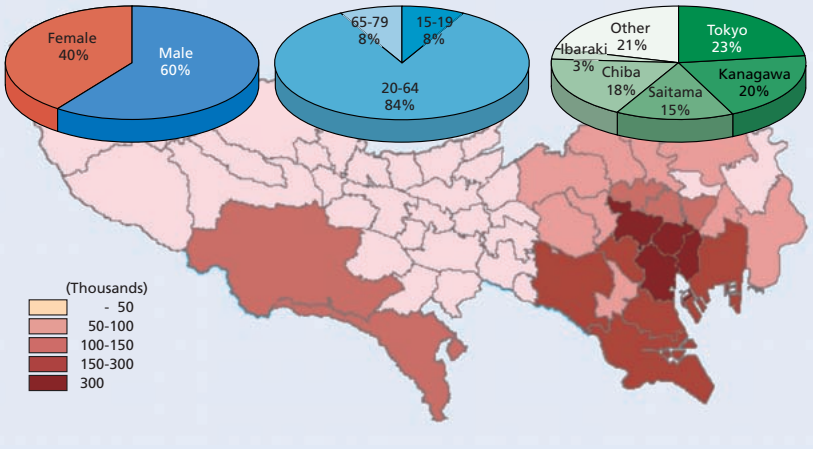


Figure 1 Number of stranded people across the whole of Tokyo, broken down by time of disaster occurrence

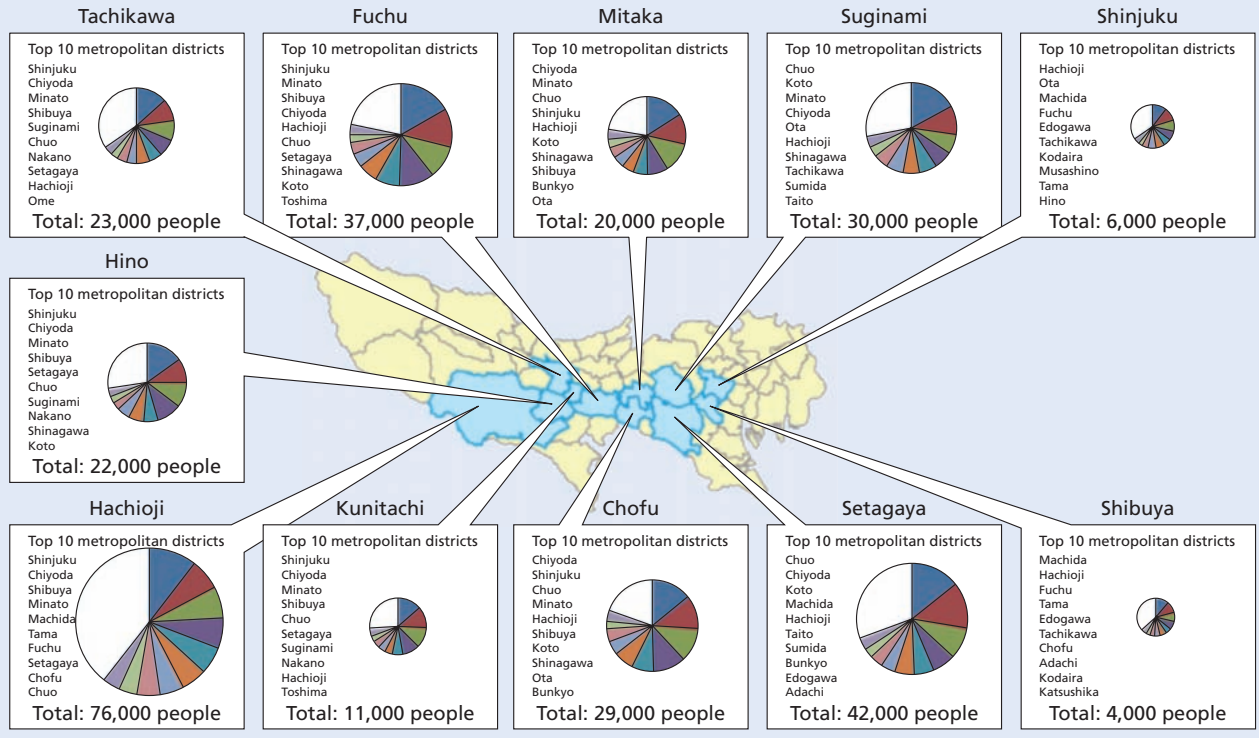


Source of administrative division map: Digital national land information department (administrative division), Ministry of Land, Infrastructure and Transport

Figure 2 Distribution and breakdown of the number of stranded people (3 pm weekday)

the 11 metropolitan districts along National Route 20 become stranded when they are away from home while an earthquake occurs at 3 pm on a weekday. The existing damage estimates are limited to an analysis of how many people become stranded while away from home in each metropolitan district, but by incorporating new calculations of the number of people stranded while away from home, we can expect results that can be applied to the study of measures for providing people with support (e.g., by providing substitute transport such as buses).

Figure 4 shows the number of peo-



Source of administrative division map: Digital national land information department (administrative division), Ministry of Land, Infrastructure and Transport

Figure 3 Number of residents who will become stranded (3 pm weekday)

ple returning home on foot who flow into the eleven metropolitan districts when there are affected people from Tokyo and its neighboring prefectures walking home immediately after the occurrence of an earthquake at 3 pm on a weekday. The number of people walking home in each metropolitan district has not been analyzed before, and this result can be expected to be applied to resolving issues such as the over- or under-assessment of provisions for support stations to support people walking back home after a disaster.

As described above, the use of MSS makes it possible to resolve the four issues listed in chapter 1, and to study concrete measures for dealing with people who have become stranded.

4. Example of a Specific Study Taking Shinjuku as a Model Case

In the estimation of damage in Tokyo, there would be approximately 680,000 affected people in Shinjuku ward, of which approximately 350,000 would become stranded. In the following, based on the estimated results based on MSS, we studied specific measures for affected and stranded people from five viewpoints.

4.1 Dealing with and Supporting Affected and Stranded People

Figure 5 shows the numbers of affected people and stranded people in Shinjuku that would occur after disasters occurring at different times of day. The number of commuters, students etc. in Shinjuku starts to rise sharply from 7 am. When a disaster occurs during office hours on a weekday the number of affected people reaches a maximum of approximately 740,000 (4 pm) centered on the business district, and up to 340,000 (3 pm) will become stranded. In particular, it is important to provide temporary accommodation using the business district's disaster prevention resources (indoor and underground spaces, etc.), and for business operators

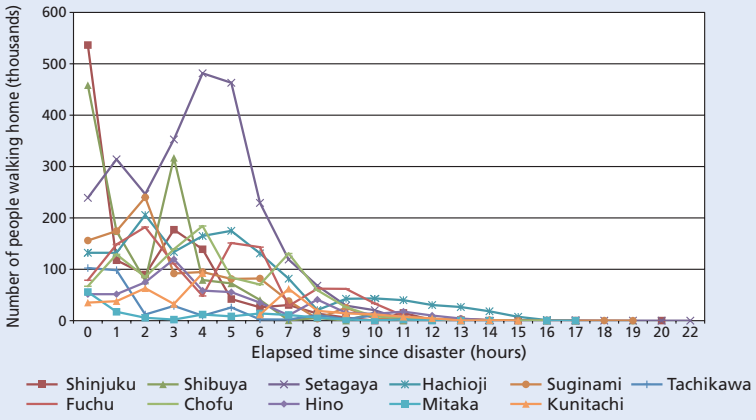


Figure 4 Number of people walking home, broken down by elapsed time since disaster (3 pm weekday)

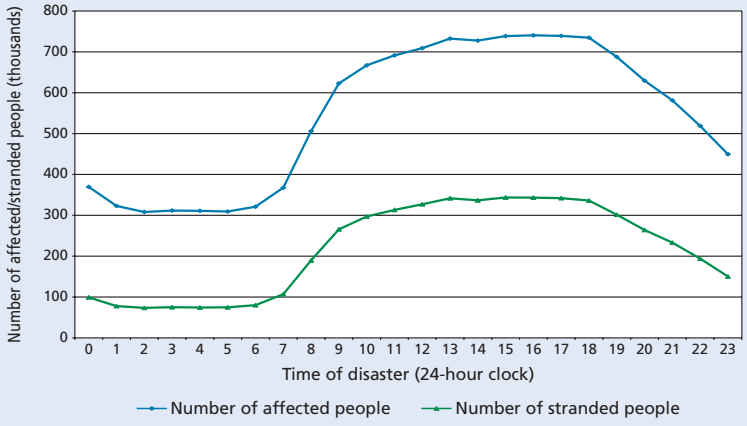


Figure 5 Numbers of affected people and stranded people in Shinjuku that would occur after disasters occurring at different times of day (weekdays)

to cooperate to prevent confusion and supply information quickly.

4.2 Dealing with and Supporting People who Need Support and Protection in a Disaster

With regard to the number of stranded people in Shinjuku due to a disasters occurring at various times of day on a weekday, **Figure 6** shows a breakdown of the results by gender, **Figure 7** shows a breakdown by age group, and **Figure 8** shows a breakdown by the areas in which people live. In a disaster occurring on a weekday during office hours, the stranded people would include many people liable to become stranded and require support, such as women and the elderly (Figs. 6 and 7). In particular, since the stranded people have no choice but to stay temporarily until the safety of the surrounding regions has been confirmed, it is necessary for the facilities that admit them have reserves that give due consideration to people needing assistance during a disaster and to barrier-free accessibility using both soft and hard measures.

Also, during office hours on a weekday, there are many visitors and sightseers from beyond nearby prefectures, resulting in a greater number of stranded people (Fig. 8). For a disaster occurring at 6 pm on a weekday, the number of such people requiring assistance would be approximately 80,000.

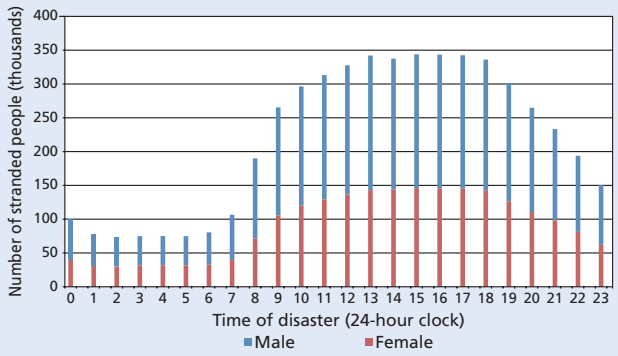


Figure 6 Numbers of stranded people in Shinjuku, broken down by gender and time of disaster (weekdays)

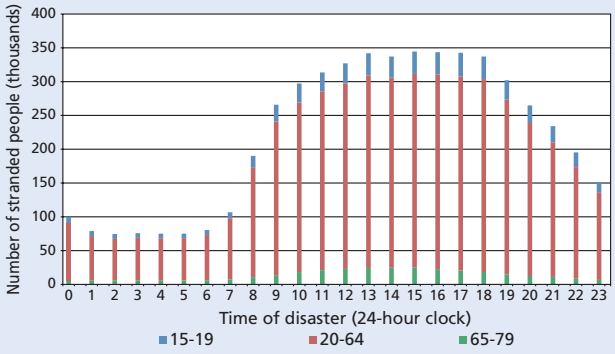


Figure 7 Numbers of stranded people in Shinjuku, broken down by age group and time of disaster (weekdays)

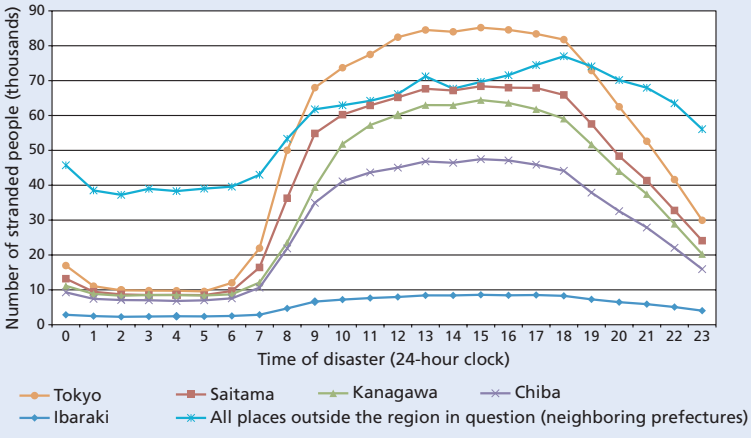


Figure 8 Numbers of stranded people in Shinjuku, broken down by areas in which people live and time of disaster (weekdays)

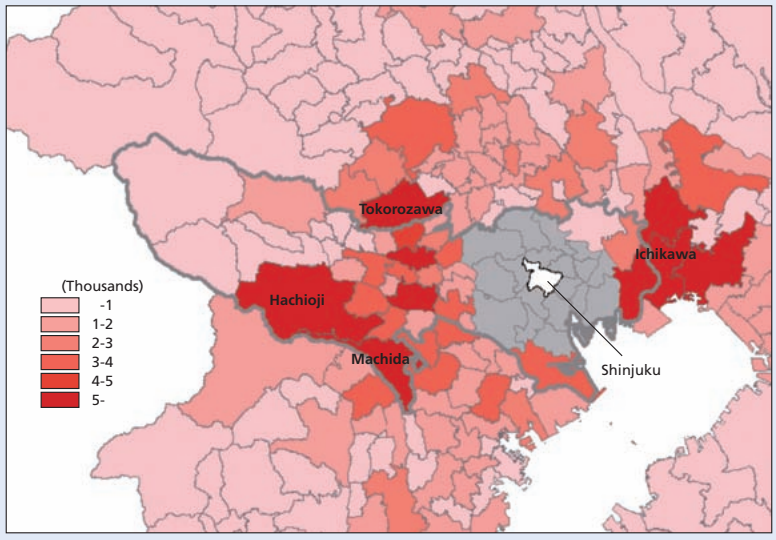
In particular, at nighttime they would tend to outnumber the stranded people who live in neighboring prefectures. Unlike stranded people who live in Tokyo or in neighboring prefectures, these people would have to be looked after for an extended period until transportation to outside of the disaster region has been restored. A support system needs to be set up for these people in cooperation with hotels and the like that can provide them with long-term accommodation.

4.3 Helping People Get Home in Collaboration with Neighboring Metropolitan Districts and Prefectures

Figure 9 shows a breakdown of the residential areas of people stranded in Shinjuku in the case of a disaster occurring at 3 pm on a weekday. In addition to the cities of Hachioji and Machida, which lie within the Tokyo metropolitan area, the stranded people also include citizens of cities such as Ichikawa and Tokorozawa that lie in other prefectures, and people such as sightseers from outside the neighboring prefectures as shown in Fig. 8. There is consequently a need for measures to help people return home through wide-ranging cooperative measures including the collection of support information in collaboration with local authorities over a wide area and the provision of this information to stranded people, and the implementation of staggered homeward travel plans in collaboration with large-scale terminal stations and other stations that can help people return home along routes where people are supported in returning home.

4.4 Dealing with and Supporting People Walking Home that Flow in from Other Districts

Figure 10 shows the results of



Source of administrative division map: Digital national land information department (administrative division), Ministry of Land, Infrastructure and Transport

Figure 9 Distribution of the residential regions of people stranded in Shinjuku (3 pm weekdays)

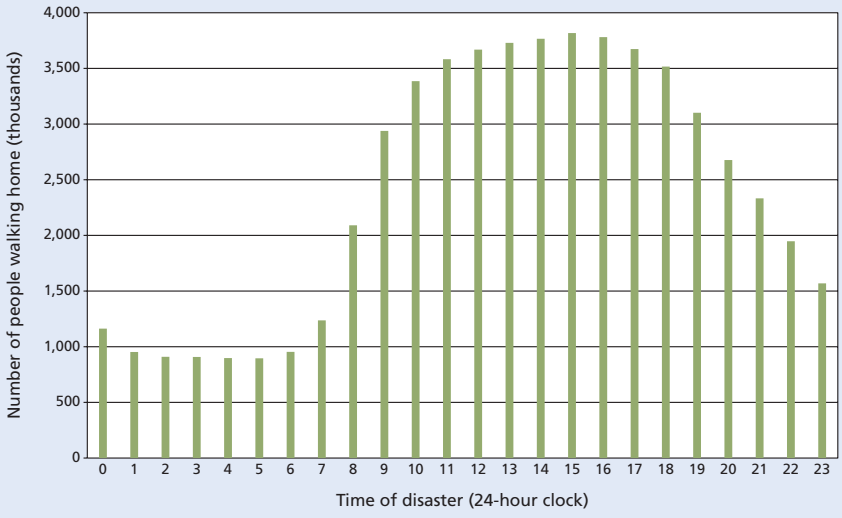


Figure 10 Number of people walking home through Shinjuku that would occur after disasters occurring at different times of day (weekdays)

aggregating the number of people returning home on foot after an earthquake that pass through Shinjuku on their way home, broken down by the time of day at which the disaster occurs. In addition to dealing with people that become stranded in Shinjuku, it is also necessary to deal with people walking home that pass through Shinjuku on the way. The number of people walking home through Shinjuku varies depending on the time of day at which the disaster occurs. For example, a disaster at 3 pm on a weekday would result in approximately 3.82 million people passing through Shinjuku as they walk home (Fig. 10). These people will need temporary rest and toilet facilities, along with measures such as resources and information to help them find their way home. This sort of assistance and support for people passing through on foot while walking home is something that needs to be studied.

4.5 Raising Awareness among Residents

In the event of a large-scale earthquake, it is possible that Shinjuku residents may become stranded while staying in various places in Tokyo or in other prefectures or the like. For example, in the event of a disaster occurring at 3 pm on a weekday, approximately 60,000 Shinjuku residents would become stranded elsewhere in Tokyo, and there would be many people stranded in places such as Hachioji city, Ota ward and Machida city (**Figure 11**). The residents of Shinjuku need to be shown this information and asked to prepare their own individual self-help measures for such a situation. The promotion of self-help measures helps to ensure the safety of citizens, and helps prevent the chaos and secondary damage that would occur if everyone tried to return home at once.

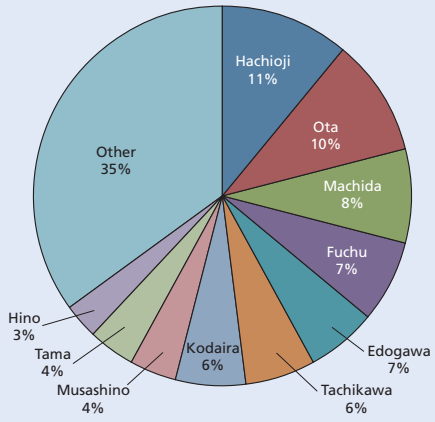


Figure 11 Breakdown of Shinjuku residents who become stranded in other parts of Tokyo (3 pm weekday)

5. Conclusion

As reported in this article, MSS can resolve the issues of the traditional damage estimation method, such as its inability to reflect the latest demographics, its inability to consider what would happen at different times of day, its inability to consider visitors from beyond the neighboring prefectures, and the lack of information broken down by gender or age group. As a result, we have confirmed that MSS are useful for concrete studies of how to deal with people who have become affected or stranded due to a disaster occurring at a particular time of day, and for dealing with the arrival of people from other regions. However, these estimations are produced based on just one week's data and model metropolitan districts as individual units, In the future, we will continue with research aimed at understanding the differences between months and seasons by performing measurements throughout the year and performing estimations at a more geographically detailed level to assist in the formulation of advance plans so as to avoid confusion among people that are stranded when an emergency arises.

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