Analyzing problems of district-based administration using Monte Carlo simulation: the case of sex offenders notification

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Abstract. The problems of administration simply based on administrative unit that does not consider the operational purpose of the system have been consistently mentioned. For example, in the Republic of Korea, sex offenders information is notified by mail only in some regions. However, the information of sex offenders is notified based on the administrative 'Dong' of the offender's residence, so even if you live in the building next to the offender, you cannot be notified because the dong of residence is different. Therefore, in this study, the problems of administration that did not consider the realistic scope were analyzed using the case of sex offender. By expanding the distance, we derived the extent of the sex offenders notification problem. Also, in order to determine whether this problem occurred by chance at a specific point in time or a fundamental limitation in administration, Monte Carlo simulation were applied to compare the degree of problems in actual residence and random residence data.

Keywords. Administrative district, Sex offender, Monte Carlo Simulation

1. Introduction

The Republic of Korea has administrative districts such as Gu and Dong within cities and Seoul has 25 Gu and 426 Dong. Administration is handled based on them, however, administration based on administrative unit that does not consider the operational purpose of the system continues to be an issue. For example, in the field of nuclear safety (radioactive leak) crisis

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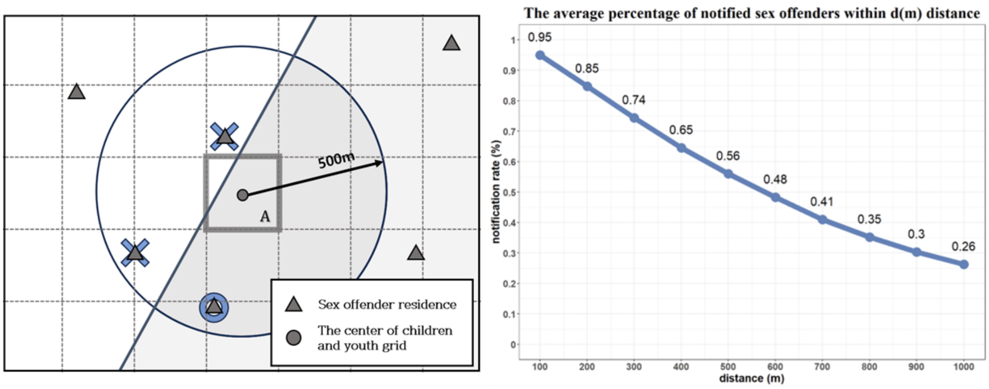
response practice manual, when a fire or radioactive leak accident occurs, the designation of the fire department is based on the administrative district. Accordingly, even though there was a 911 safety center 2km away, the center 11 km away was designated as the fire department in charge, which took more than 5 times longer to respond (Park, 2020). It was pointed out that the designation of center based on administrative districts was not suitable for safety fields requiring rapid response, so the designation of fire departments was changed based on distance.

The need to consider the distance standard when setting the scope can also be found in the issue of notifying sex offenders. In the Republic of Korea, sex offenders information is notified by mail only in some regions. Currently, the information of sex offenders is notified to household and institutions that protect children and youth in the administrative dong where the offender resides. According to Kim and Jung (2011), sex offenders are more likely to commit crimes in familiar places than unfamiliar places, and more than half of sex crimes against minors occur in areas near to the offender's residence (Gu 2023). However, the administrative dong based information notification system has a limitation in that information is not notified to residents who actually need the information, as even if the offender lives in the building next door, information cannot be notified unless they live in the same administrative dong. Therefore, in order to provide practical information, it is necessary to revise the system such as notification considering the distance from their residence.

This study aims to analyze the limitations of administrative district unit administration using the sex offender notification issue as a case. To this end, by increasing the distance centered on the children and youth grid, derive the number of sex offenders living in the nearby area, the ratio and the distance of sex offenders for whom information is not notified. In addition, to confirm that these problems do not occur only in certain residence types, Monte Carlo simulation was used to compare the degree of sex offender notification problems in the residence distribution of this study and random types. Before starting the analysis, sex offender data was referenced on the sex offender notification website(https://www.sexoffender.go.kr/), and to protect personal information, the imported data was anonymized and actual residences were not visualized.

2. Spatial analysis of the current notification system limitations

To determine the notification rate of sex offenders living nearby, analyze as shown in *Figure 1 (a)*. In Grid A, there are a total of 3 sex offenders within 500m, of which there is 1 offender for whom information can be notified, and there are 2 offenders for whom information cannot be notified because they do not reside in the same administrative district. Therefore, the notification rate of the grid A can be calculated as 33.3%. This was calculated for all grids within the study area, and the number of children and youth within the grid was applied as a weight. So, if p_i denotes the number of children and youth in gird i, a_i denotes the number of sex offenders residing in the same dong as gird i within d distance, t_i denotes the number of sex offenders within d distance from gird i, the average percentage of notified sex offenders within d distance($P(d)$) can be calculated as *Equation 1*.



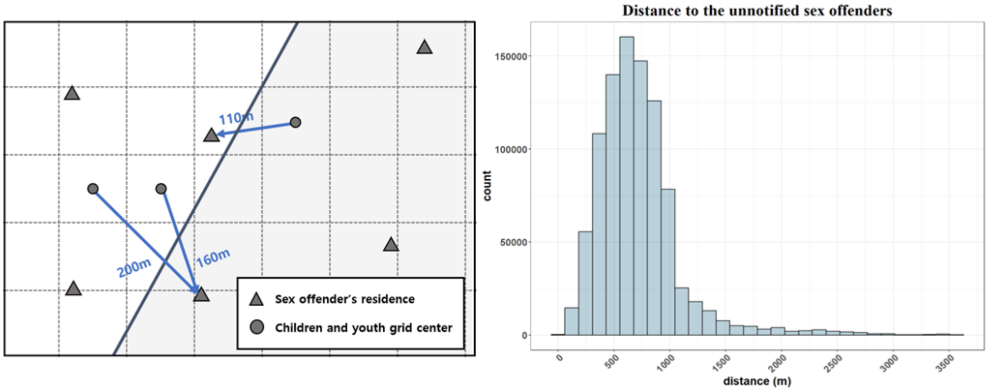
(a) **(b)**

Figure 1. (a) How to calculate notification ratio, (b) Result of notification ratio

$$P(d) = \frac{\sum_{i=1}^{n} p_i x_i}{\sum_{i=1}^{n} p_i}\ , \quad x_i = \frac{a_i}{t_i} \qquad (n:\ Total\ number\ of\ grids) \qquad \textbf{Equation 1}$$

Centered on children and youth grid, the calculation in 100m increments from 100m to 1km is shown as *Figure 1 (b)*. As a result of the calculation, the average notification rate of sex offenders per 500m is approximately 0.56. This means that, for example, if 4 sex offenders live within 500 m of a children and youth, half of them(2 sex offenders) will not be notified.

Next, as shown in Figure 2 (a), in order to find out how close children and youth live to sex offenders for whom information has not been notified, the distance to the nearest offenders who do not live in the same administrative district around each grid was calculated. As in the previous analysis, the number of children and youth in each grid was applied as a weight, and calculated for all grids in the study area to derive the distribution shown as *Figure 2 (b)*. As a result of the analysis, it was confirmed that approximately 255,000 children and youth(28% of the total) live within 500m of the unnotified offender.



(a) **(b)**

Figure 2. (a) How to calculate distance, (b) Distance to the unnotified sex offenders

3. Monte Carlo simulation

In the study, using residence data of sex offenders at a specific point in time, analyze the vulnerabilities of the information notification system at the administrative district unit. Therefore, it is necessary to determine whether the results appeared by chance at a specific point in time or due to fundamental limitations of information notification at the administrative district unit, because the analyzed results are dependent on the distribution of offenders' residences. Accordingly, we performed a Monte Carlo simulation-based verification that compared the results of the analysis based on the actual offenders' residence with the results of sufficiently repeated analysis based on the random residences generated by random numbers. To do this, we built a model that generate random residences and calculate the notification rate or the distance to sex offenders who were not notified in the generated residence type. The pseudocode for the Monte Carlo simulation applied to each is shown in Figure 3, and it was programmed using R 4.2.2 x64. The simulation was performed 999 times with reference to previous research. After the simulation, the results were ranked from lowest to highest. To compare the randomly generated residence-based analysis results with the actual residence-based analysis results, a 95% confidence interval was derived by excluding the top 50(or bottom 50) observations among the sorted statistics. And, if the actual residence-based analysis results were included in the confidence interval, the degree of information notification problems occurring in the two types of residence were considered to be similar, it was considered that problems similar to the analysis results would occur in any type of residence. As a result of the analysis, it was confirmed that problems similar to those in this study occur in any type of residence.

Nomenclature			
S	Number of iterations	G	Entire grid
T_j	Number of sex offenders residing within 500m from grid j	C_j	Number of children and youth in grid j
A_j	Number of sex offenders residing in same dong as grid j and within 500m	K_j	kth nearest offenders by grid j
A	Percentage of notified offenders	$D_{(j,l)}$	Distance of data j and l
C	Entire number of children and youth	D	Distance from sex offenders who are not notified

Percentage of notified sex offenders	Distance from sex offenders who are not notified
for $\forall i \in S$ Generate residence points in random for $\forall j \in G$ $A \leftarrow (A_j / T_j) C_j + A$ $C \leftarrow C_j + C$ end for A/C end for	for $\forall i \in S$ Generate residence points in random for $\forall j \in G$ for $\forall l \in K_j$ if $j_{Dcode} \neq l_{Dcode}$ then Calc. $D_{(j,l)}$ break end for $D \leftarrow D_{(j,l)} C_j + D$ end for D/C end for

Figure 3. Pseudo code of Monte Carlo

4. Conclusion

In this study, the problems of administration based only on fixed areas such as administrative districts without considering the spatial scope according to the purpose of the system was examined, using the case of sex offender information notification. And Monte Carlo simulation was applied to confirm that this problem does not occur only in a specific type of residence. As a result of the study, it was possible to identify children and youth households that living close to sex offenders but were not properly informed, and it was confirmed that this problem occurs even in any residential type. Since the issue of offender information notification can be directly related to the safety of the citizens, it is necessary to properly inform the citizens who need the information. Simply setting the scope of administrative district without considering the purpose of the system has the problem of adding administrative inefficiency and inconvenience to daily life in system where distance is important. Therefore, for a practical and systematic response, it is essential to consider the spatial perspective when setting up the work area. In this respect, this study is expected to be used as basic data for improving administration simply based on administrative districts without considering realistic scope.

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