
# Assessment of the Quality of EMS Incident Location Documentation in WEMSIS

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Better adapting to geographic information system (GIS) analysis is just one of the ways the WEMSIS team can share the information reported to the system in support of DOH's Transformational Plan. However, without a thorough assessment of the location information, the WEMSIS team is unable to fulfill this purpose. The intent of this report is to assess the completeness of WEMSIS data fields needed to geocode EMS incident locations using GIS software. In this report, we summarize field completeness over time and compare information entered separately in address and GPS coordinate fields.

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**Assessment of the quality of EMS incident location documentation in Washington Emergency Medical Services Information System (WEMSIS)**

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A key strategy in the Department of Health's 2022 Transformational Plan is to support innovative health information technologies that will enable partners to access and exchange health information. Better adapting to geographic information system (GIS) analysis is just one of the ways the WEMSIS team can share the information reported to the system to support this goal. However, without a thorough assessment of the location information, the WEMSIS team is unable to fulfill this purpose. The intent of this report is to assess the completeness of WEMSIS data fields needed to geocode EMS incident locations using GIS software. In this report, we summarize field completeness over time and compare information entered separately in address and GPS coordinate fields.

1. Completeness of Incident Location Fields

EMS incident location information is entered in one of two ways, neither of which are required to submit a record. First, the location can be entered as an address. Second, the EMS unit may record the GPS coordinates of the incident location. Each of these methods come with the potential for error. Documenting the address requires multiple entries to get an accurate location, as in entering a street address, city, and zip code. As these fields are all free-text, any entry is acceptable which can lead to difficulties in geocoding. In addition to potential errors in the address fields, incident GPS coordinates may be collected differently depending on the patient care record software vendor. One concern is that if the coordinates are collected as the record is entered into a tablet, there may be a difference between the incident location and the coordinates when the record is documented after the incident, such as when the EMS unit has returned to their station. For these reasons, we compare the two sources of incident location to identify ways to improve future data collection efforts.

Table 1 includes the numbers of EMS responses excluding incidents where a location may not be identified, such as when a response is cancelled, or when the unit is on standby. A total of 4,421,114 records were assessed and an incident address was recorded in over 99.5% of records between 2017 and 2021. The high completion rate of incident address is particularly surprising because each of the incident address fields are only recommended, rather than mandatory or required.[1]

**Table 1: Completeness of Incident Location Fields**

| WEMSIS Records | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| Records analyzed | 513,224 | 820,927 | 959,039 | 997,327 | 1,130,597 |
| Percent with an address | 99.8% | 99.7% | 99.6% | 99.6% | 99.5% |
| Percent with coordinates | 23.2% | 41.5% | 51.7% | 55.3% | 51.3% |

Incident GPS coordinates, an optional field, were recorded far less than the incident addresses, ranging from 23.2% recorded in 2017 to 55.3% recorded in 2020. While initially concerning, the slight dip in GPS coordinates recorded between 2020 and 2021 was related to the overall increase in reporting

[1] Recommended fields may be recorded as "Not Applicable", "Not Recorded", or blank with no error or warning message.

to WEMSIS that occurred in 2021 and not to any EMS services that stopped recording coordinates. Though it is possible that GPS coordinates could be recorded instead of the incident address, most of the records that were missing an incident address were also missing GPS coordinates. However, the records with two sources of incident location can then be used to assess the quality of the incident locations being entered.

2. Geocoding of Incident Addresses

GIS analysts at DOH were enlisted to assist in the geocoding process. Esri ArcGIS software was used to match the nearly 4.4 million incident addresses to a street grid system made available by the Office of Financial Management. Matches between the incident address and the street grid with a match score of above a 75 out of 100 were counted as matches, and any incident address with a tied match score between two or more street grid addresses was excluded from this analysis.[2] As the street grid system used for geocoding included only streets in Washington, matches of out-of-state incidents were likely incorrect and excluded from further analysis.

Table 2 includes the number of EMS responses to emergencies where patient contact was made. This set of records was chosen to reflect the data most useful for future analysis, such as assessment of EMS care access or response times. A total of 3,549,330 records went through the geocoding process, with matches made for at least 92% for each of the years included.

**Table 2:**

| WEMSIS Records | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| Responses to emergencies within WA state with patient contact | 388,162 | 664,561 | 777,446 | 806,727 | 912,434 |
| Percent with a geocoded address | 92.6% | 92.3% | 92.8% | 92.8% | 93.0% |
| Percent with coordinates and a geocoded address | 21.6% | 36.3% | 48.3% | 52.7% | 50.1% |

As in Table 1, the third row of Table 2 shows the percent of records with GPS coordinates. The relatively small difference between records with coordinates in either table suggests that data quality from either source is related. A $\chi^2$ test between whether the address was able to be geocoded and whether the coordinates were recorded confirmed that records with no coordinates also had lower quality address information.[3] Going forward, this subset of records could be a focus in efforts to improve incident data collection. It is possible that some of the incident addresses were already geocoded by a software vendor and their coordinates reported through to WEMSIS. Additional follow-up with software vendors may be helpful in informing agencies of the best and easiest data entry practices.t

[2] Tied matches could be included in any future analysis with sufficient time for processing.

[3] Probability of the null hypothesis of independence: 0.000

3. Distance between GPS Coordinates and Addresses

Following the geocoding process, the distances between the nearly 1.5 million geocoded address points and their corresponding GPS coordinates were calculated using GIS software. Table 3 includes the shares of geocoded records that fall into one of the following categories: within 500 feet, between 500 and 1,000 feet, between 1,000 feet and one mile (5,280 feet), and over one mile. For each year, between 83 and 88% of geocoded incident locations were within 500 feet of their coordinates. Around an additional 8% were between 500 and 1,000 from their GPS coordinate, totaling to over 90% within 1,000 feet.

**Table 3: Distance from GPS Coordinates to Geocoded Addresses**

| WEMSIS Records | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| Percent within 500 feet | 85.1% | 83.0% | 83.9% | 84.2% | 87.8% |
| Percent between 500 and 1000 feet | 8.4% | 8.2% | 7.6% | 8.0% | 8.2% |
| Percent between 1,000 feet and one mile | 5.5% | 7.8% | 7.5% | 6.8% | 3.0% |
| Percent over one mile | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |

Between 6 and 9% of incident locations were more than 1,000 feet from their coordinate and 1% each year was over one mile from their coordinate. One potential explanation for differences between GPS coordinates and addresses is the process of collecting GPS coordinates. If the coordinates are automatically collected by a tablet as the record is entered, there may be large differences when there is a delay between when the incident occurs and when it is recorded. As an extreme example of this, coordinates recorded during an air transport would be very far from the actual incident location shortly after leaving the scene. To test this, we performed a $\chi^2$ test between whether the incident was an air transport and whether the distance from address to coordinates was more than 1,000 feet, and found that incident with large differences between points were disproportionately reported in air transports.[4] Future geocoding efforts should consider excluding coordinates reported near the units' station as a way of reducing this error.

Some of the difference between address and coordinates could be related to the precision of the recorded coordinates. Truncating the coordinates by one decimal point could mean a difference of up to 360 feet when three decimals are recorded and 3,600 feet when only two decimals are recorded. Additionally, there were 29,060 records where the county identified through geocoding differed from the county reported to WEMSIS. The majority of these occurred near county boundaries and were less common when boundaries were clearer, such as when counties are separated by a body of water. This suggests that the county provided through geocoding may be preferable when conducting analysis by incident county.

On the last page of this report, we've included a map showing the variation in the percent of addresses geocoded for each WA county in 2021. Most of the counties in western and south central Washington have high geocode percentage rates, while many counties in eastern have low geocode percentage rates. Five counties fall into the lowest category with less than 80% of addresses geocoded.

[4] Probability of the null hypothesis of independence: 0.000

This gap in data quality in many rural counties adds to the existing gaps in reporting to WEMSIS in rural areas. The values shown on each county are the number of geocoded emergency responses with patient contact. These records are those available for spatial analysis.

4. Summary and Next Steps

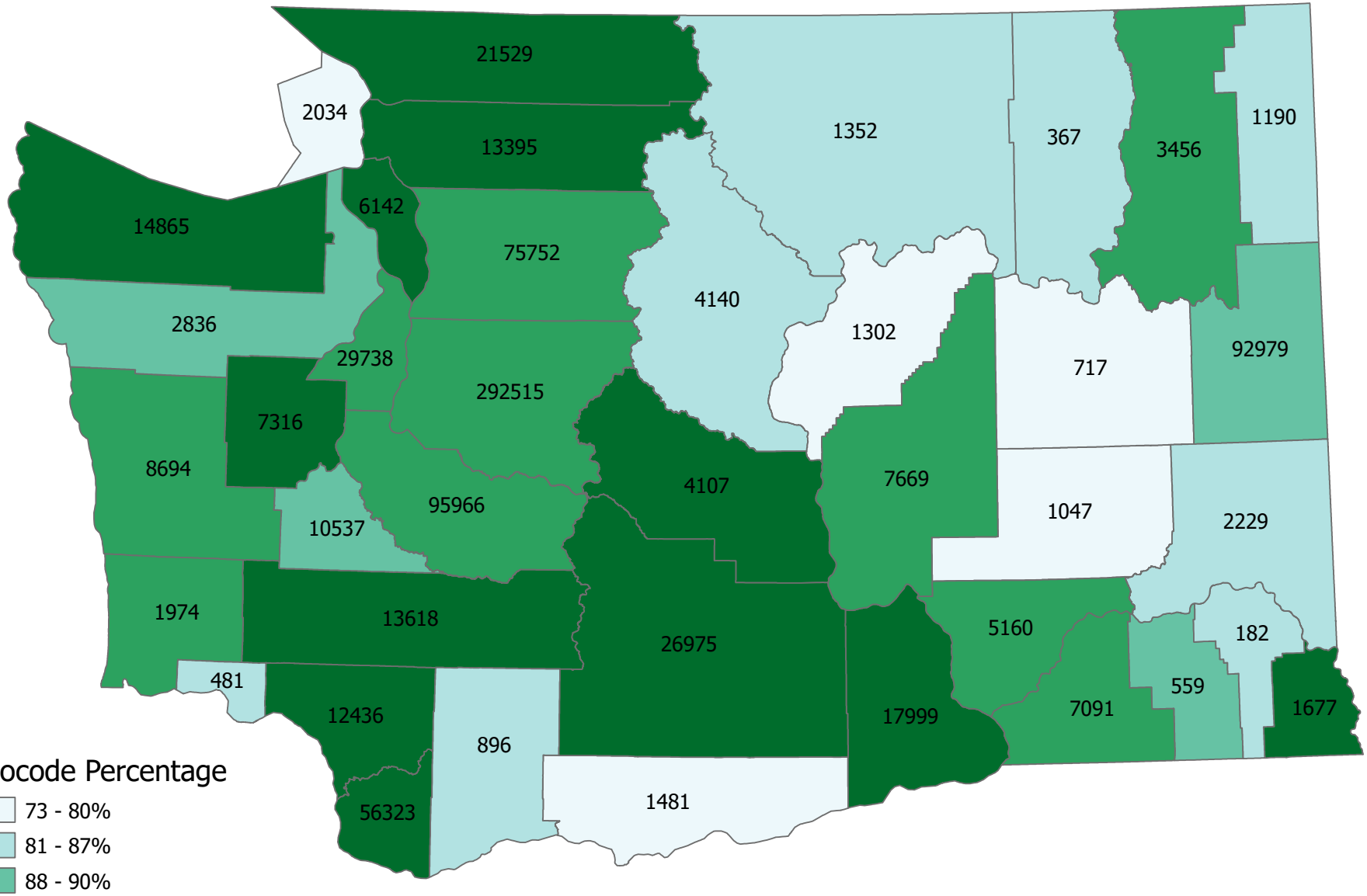
The WEMSIS team, with assistance from DOH GIS analysts, geocoded EMS incident locations for the years 2017 through 2021. A total of 3,292,263 emergency patient contact incident addresses were successfully geocoded with 44.6% of these also having GPS coordinates in the incident record. For geocoded records with coordinates, we assessed the distance between sources of location. Between 83 and 88% of geocoded incident addresses were within 500 feet of their reported coordinates each year. Geocode rates have remained steady at around 93%, and location documentation and accuracy improved in later years, even as records reported to WEMSIS increased. In terms of overall quality, incident addresses are preferable for use in spatial analysis, and the county identified through geocoding has better accuracy than the county reported to WEMSIS, especially when county boundaries are not clear.

The assessment revealed ways to improve the next round of EMS incident geocoding. Records without coordinates also had lower quality addresses for geocoding and could be a focus for data quality improvement efforts. Five counties were identified with a geocode rate of below 80%. The difference between incident addresses and coordinates is likely related to incidents where there is a delay in collection of coordinates. Using a street address grid that includes Idaho and Oregon could improve results around Washington's border and reduce geocoding error. Further analysis considering the precision of coordinates and type of incident location could also reveal the cause of differences between address and coordinates. For example, incidents in intersections or along highways may have higher error in their address than their coordinates. Special attention to these issues will likely improve future geocoding results.

Going forward, the processed data and lessons learned from this assessment are valuable tools for future research. For 2021 alone, the analysis provided 848,726 EMS incident location points to use in spatial analysis, such as estimation of EMS service areas or response and transport time mapping. While improvements are still needed in EMS reporting and quality in select counties, the results are an important step in using and understanding all of the data reported to WEMSIS.

# Incident Location Geocode Quality for 2021

The percent of incident addresses reported to WEMSIS that were able to be geocoded. Values on each county denote the number of emergency responses with patient contact where the incident location was geocoded.




Data sources: Washington EMS Information System (WEMSIS); Office of Financial Management