SIDARTHa
European Emergency Data-based Syndromic Surveillance System

Executive Agency for Health and Consumers
Directorate-General for Health & Consumers

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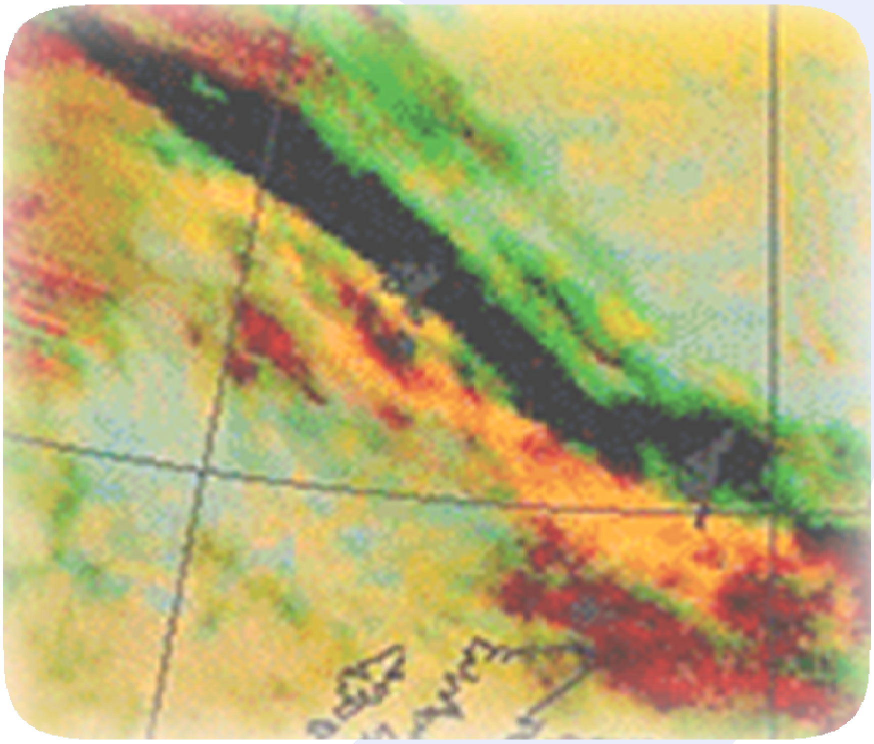
European Emergency Data-based Syndromic Surveillance System
Grant Agreement No. 2007208

# SIDARTHa Volcanic Ash Cloud Rapid Public Health Impact Assessment

## Regional public health impact of volcanic ash cloud covering Europe after eruption of Eyjafjallajoekull, Iceland starting April 14th, 2010

Results as of May 15th, 2010



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## SIDARTHa Volcanic Ash Cloud Rapid Public Health Impact Assessment

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### Results as of May 15th, 2010

This report provides a rapid regional public health impact assessment of the volcanic ash cloud that covered Europe after the eruption of the Eyjafjallajoekull volcano in Iceland starting on April 14th, 2010. The analyses are based on routinely collected emergency medical data (emergency medical dispatch centre, emergency physician service, emergency department) from the SIDARTHa implementation sites in the State of Tyrol/Austria, the County of Goeppingen/Germany, and the Autonomous Region of Cantabria.

Compiled by

Nicole Rosenkötter, Alexandra Ziemann, Luis Garcia-Castrillo Riesgo, Gernot Vergeiner, Matthias Fischer, Thomas Krafft, Helmut Brand

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Cover Figure

Modified part of a EUMETSAT satellite image provided by Met Office UK showing the volcanic ash cloud spread on April 15th, 2010 at 15:30GMT; downloaded from http://news.bbc.co.uk/2/hi/uk_news/8625813.stm; accessed April 27th, 2010



SIDARTHa Scientific/Technical Coordination Office, c/o GEOMED Research Forschungsgesellschaft mbH, Hauptstr. 68, 53604 Bad Honnef, Germany, Tel. +49 2224 7799896, Fax. +49 2224 7799897, mail@sidartha.eu, www.sidartha.eu

# 1 Background & Objectives

Syndromic surveillance can detect public health threats earlier than traditional surveillance and reporting systems based on laboratory confirmations. Pre-hospital emergency medical services and emergency medical dispatch centres, and in-hospital emergency departments across Europe routinely collect electronic data that provides the opportunity to be used for near real time syndromic surveillance of communicable and non-communicable health threats such as heat-related diseases or Influenza-Like-Illness. The European Commission co-funded project SIDARTHa (Grant Agreement No. 2007208) for the first time systematically explores the use of emergency data to provide a basis for syndromic surveillance in Europe. The SIDARTHa project provides a methodology and software application for syndromic surveillance at the regional level[1] in Europe based on routinely collected emergency data. It is expected that SIDARTHa improves the timeliness and cost-effectiveness of European and national health surveillance by providing a basis for systematic syndromic surveillance that supplements the existing surveillance structures. The project started in June 2008 and will run until December 2010. It is an initiative of emergency medical professionals organised in the *European Emergency Data (EED) – Research Network*[2]. Further information on the SIDARTHa project can be found under www.sidartha.eu.

**With the spread of the volcanic ash cloud[3] across Europe after the eruption of the *Eyjafjallajoekull* volcano in Iceland starting April 14th, 2010, the SIDARTHa consortium developed the idea to accomplish a rapid assessment on the potential public health impact of the ash cloud in the implementation sites of the SIDARTHa project[4].**

**The objective of the analysis was to assess if the SIDARTHa system is able to immediately analyse upcoming potential health threats and to use this surveillance system to investigate if the overall as well as the syndrome- or severity-specific number of cases increased significantly from the expected number of cases during the volcanic ash cloud period (April 14th to 22nd, 2010).**

**This report presents results as of May 15th, 2010.**

[1] In the SIDARTHa project the term *regional* is used referring to the smallest administrative level at which a health authority responsible for surveillance and reporting is established in a European country depending on the national definition and rules. This level can be a community, city, county, district or state. The implementation of the SIDARTHa syndromic surveillance system can be based on data collected for the same administrative level or also for a part of this area or based on the catchment areas of one or more participating emergency institutions.

[2] www.eed-network.eu

[3] This report uses the term 'volcanic ash cloud' without determining if the ash cloud was a cloud or rather a contamination. Therefore it should be understood that the term 'ash cloud' used throughout this report is not to be understood as a scientific term. It should be further noted that the authors do not intend to give any prejudice on the question if there was any risk to health at all caused by the ash cloud as such. The intention of this rapid assessment was to test the capability of the SIDARTHa concept and pilot syndromic surveillance system to be timely adjusted for monitoring a suddenly occurring event potentially affecting health.

[4] SIDARTHa Implementation sites: State of Tyrol, Austria; Capital Region, Denmark, County of Goeppingen, Germany, Autonomous Region Cantabria, Spain

# 2 Material & Methods

The SIDARTHa implementation sites were selected to function as case studies. Emergency medical data sets (emergency medical dispatch centre, emergency physician service, and emergency department) from Austria (State of Tyrol), Germany (County of Goeppingen) and Spain (Autonomous Region of Cantabria) were analysed to monitor potential public health effects of the volcanic ash cloud. Since only selected regions were used from these countries the results are not representative for the whole country.

The ash cloud exposure differed for the implementation sites. Based on information from the Met Office UK for April 14th to 23rd, 2010 the ash cloud probably covered the implementation site in Germany from April 15th to 22nd, the implementation site in Austria was probably exposed from April 16th to 21st and the implementation site in Spain from April 17th to 18th, 2010.[5] In the following analysis a general volcanic ash cloud period is indicated as period under study. This period includes April 14th to 22nd, 2010 so regionally specific periods of exposure are covered.

The data sets were used to analyse the overall number of cases per day as well as (if possible) the age distribution and the syndrome- or severity-specific proportion of cases focusing on respiratory and cardiovascular diseases (the syndrome definitions based on Advanced Medical Priority Dispatch System codes and International Classification of Diseases (ICD-10) can be found in Appendix 1 and 2 respectively). Since it can be assumed that due to flight restrictions the road traffic increased the data from Austria was also analysed for higher incidence in traffic related injuries (cf. Appendix 1 for the syndrome definition). Data sets from the other regions did not provide such specific information to analyse the number of traffic-related injuries.

For the descriptive analysis data from April 2010 was compared to reference data of 2009 or to a comparable period in April 2010 before the volcanic eruption.

### Detection algorithm

The detection algorithm C1, C2, C3[6] has been applied in order to identify unusual aberrations from baseline values that exceeded the expected demand for emergency care. The detection algorithm was used on a daily basis, which means that for each day the observed and expected values were compared and assessed. Deviations larger than three (C1, C2) to two (C3) sample standard deviations above the sample mean were defined as aberration signal. The formulas of the algorithm as well as the definition of the thresholds are given in Appendix 3.

The algorithm was applied on the total number of cases/encounters per day as well as on the proportion of syndrome- or severity-specific cases per day. The syndrome-specific proportion of cases with the respective syndrome per day was analysed as followed, e.g.:

Number of cases with respiratory syndrome on day d / total encounters on day d

Depending on day-of-the-week variations of case numbers in the specific data sets the C1, C2, C3 algorithm was either applied in a stratified or unstratified manner. The data sets were stratified for example in weekdays (Monday to Friday) and weekend days (Saturday and Sunday). Afterwards the algorithm was applied in each stratum separately.

[5] Met Office London. Volcanic Ash Advisory from London - Issued graphics. http://www.metoffice.gov.uk/aviation/vaac/vaacuk_vag.html (accessed May 4th 2010)

[6] Fricker RD, Jr., Hegler BL, Dunfee DA. Comparing syndromic surveillance detection methods: EARS' versus a CUSUM-based methodology. Stat Med. 2008 Jul 30;27(17):3407-29.

# 3 Case Study Results (as of May 15th, 2010)

## 3.1 Austria: State of Tyrol

The case study in Austria is based on data from the **Emergency Medical Dispatch Centre Tyrol** which is currently responsible for the area of the City of Innsbruck (118,035 inhabitants), the County of Innsbruck (164,027 inhabitants) and the District of Kufstein (99,394 inhabitants).

Data from April 2010 (April 1st – 21st) was available for the data analysis. Of major interest was the data from April 14th (volcanic eruption) to the most recent available data (April 21st). Data from March, April and May 2009 was used as reference.

**Overall number of cases**

From April 1st to 21st, 2010 4,091 cases were registered in the data set of the Tyrol emergency medical dispatch centre. For the same period in 2009 3,565 cases occurred.

The daily number of emergency cases in the Tyrolean database is strongly depending on the day of the week. In 2009 and 2010 there were 50 to 100 more cases during the week than on weekends. For this reason figure 1 shows the overall number of emergency medical dispatch cases in Tyrol in April 2010 and as reference the median as well as the 25th and 75th percentile of data from the same weekday (Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st). It becomes visible that the overall number of cases was often higher in 2010 compared to 2009. **But a higher number of daily cases was seen before as well as after the volcanic eruption.**

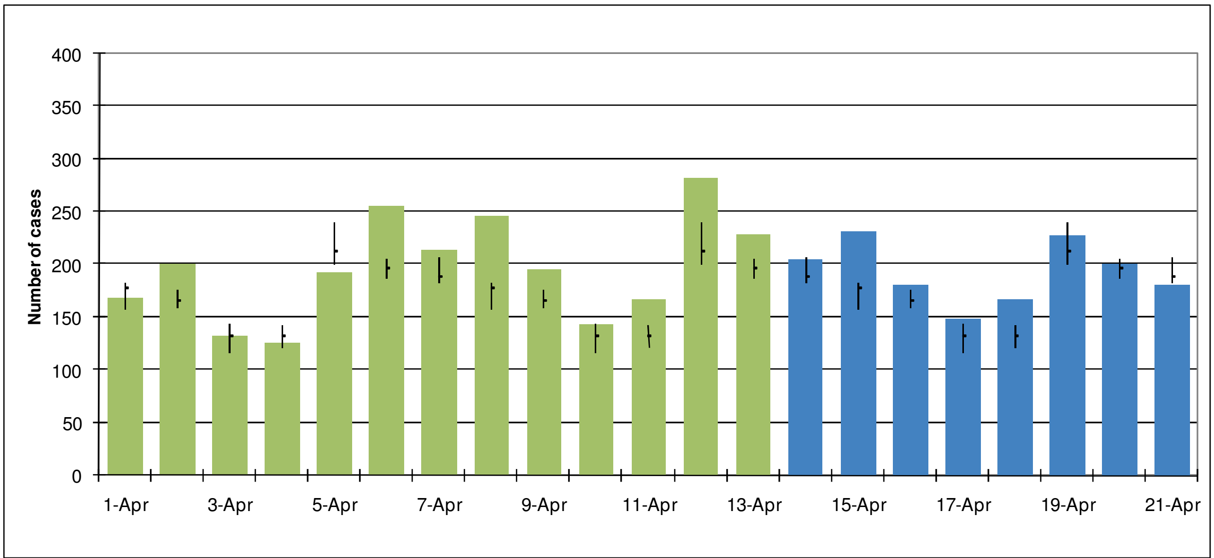


**Figure 1: Overall number of emergency medical dispatch cases in Tyrol in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile.**

## Age distribution

The analysis of the age distribution of the total number of cases during the period of the volcanic ash cloud compared to a similar period before (table 1) showed no striking differences. **The age distribution did not differ significantly between the groups in the different periods ($p>0.05$[7]).**

| Period 2010 | ≤ 1 year | 2-18 years | 19-69 years | ≥ 70 years |
|---|---|---|---|---|
| April 14th-21th | 16 (1.0 %) | 89 (5.5%) | 684 (42.3%) | 829 (51.2%) |
| April 6th-13th | 13 (0.8%) | 103 (6.0%) | 723 (42.2%) | 875 (51.1%) |

**Table 1: Total number of cases per age group during the volcanic ash cloud period in comparison to a comparable period before the eruption**

## Detection algorithm C1, C2, C3 - Overall demand

The C1, C2, C3 algorithm was applied on the overall number of cases per day separately for the stratum weekday (Monday to Friday) and the stratum weekends (Saturday and Sunday). **In April 2010 (April 1st – 21st) there were no aberrations identified which exceeded the expected number of daily cases.**

## Descriptive analysis and detection algorithm C1, C2, C3 - Syndrome-specific analysis

For the syndrome-specific calculation only those cases were included for which information on symptoms was available. In 2010 65.5% of the calls were received from other dispatch centres or other health care services for which no information on symptoms was collected.

[7] Pearson Chi-Square

Respiratory syndrome

In April 2010 (April 1st – 21st) 113 cases with respiratory syndrome were dispatched in Tyrol, on average five cases per day. During the same period in 2009 also five cases per day were registered, in total 104 cases. Figure 2 shows the daily number of patients with respiratory syndrome and as reference the median as well as the 25th and 75th percentile of cases with respiratory syndrome for the same weekday (Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st). **The number of daily cases with respiratory syndrome deviated before as well as during the volcanic ash cloud period on some days from the reference period in 2009. On April 17th and 19th the number of respiratory syndrome cases was the highest.**

**The application of the detection algorithm (C1, C2, C3) on the daily proportions of respiratory syndrome cases resulted in one aberrant signal of C1, C2 and C3 on April 19th, 2010.**

On this day the proportion of respiratory syndrome cases deviated from the expected number of cases more than three standard deviations from the sample mean (signal C1, C2 and C3). On April 19th 11 out of 50 patients (22%) were registered with AMPDS codes related to respiratory syndrome. Most of them (N=6) had breathing problems which resulted in difficulties in speaking between breaths (cf. table 2), one in combination with asthma.

On average patients with respiratory syndrome were younger (M=37.6 years, SE=10.0) than patients without respiratory syndrome (M=52.0 years, SE=3.8). **This age difference was not significant t(13.0)=1.35, p>0.05.**

**There was no spatial clustering of cases visible.**

| AMPDS code | Description | No. of cases |
|---|---|---|
| 6C1 | Not alert | 2 |
| 6D2 | Difficulty speaking between breaths | 5 |
| 6D2A | Asthma and difficulty speaking between breaths | 1 |
| 6D3 | Changing colour | 1 |
| 6D4 | Clammy | 2 |

**Table 2: Specific AMPDS codes of respiratory syndrome cases on April 19th, 2010 in Tyrol**

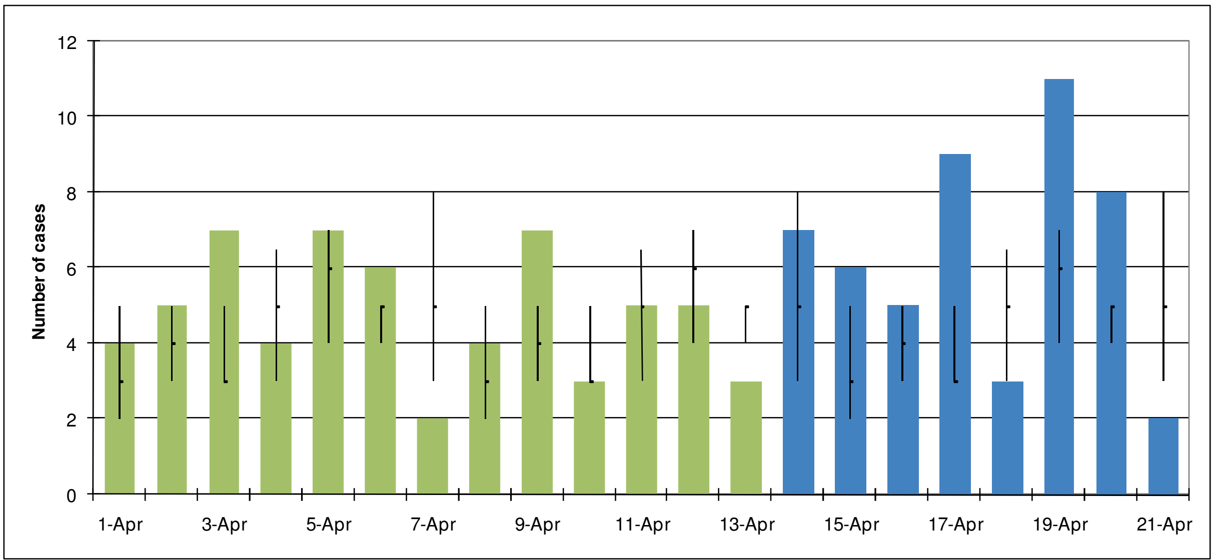


**Figure 2: Emergency medical dispatch cases with respiratory syndrome in Tyrol in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile..**

Cardiovascular syndrome

In April 2010 (April 1st – 21st) 79 cases with cardiovascular syndrome were dispatched, on average four cases per day. During the same period in 2009 also four cases per day were registered, in total 85 cases.

Figure 3 shows the daily number of patients with cardiovascular syndrome and as reference the median as well as the 25th and 75th percentile of cases with respiratory syndrome for the same weekday (Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st). The daily number of cases with cardiovascular syndrome deviated before as well as during the volcanic ash cloud period on some dates from the reference period in 2009. On April 14th the number of patients with cardiovascular syndrome was highest, but also before the volcanic ash cloud period the same number of cases was registered (April 6th). In April 2010 (April 1st – 21st) the proportion of cardiovascular cases per overall number of cases was 5.2% on average. The proportion of cardiovascular syndrome cases on April 6th was 4.7% and 6.6% on April 14th.

**The stratified application of the detection algorithm C1, C2, C3 on the daily proportion of cases with cardiovascular syndrome per overall number of cases resulted in no aberrant signal during the volcanic ash cloud period.**

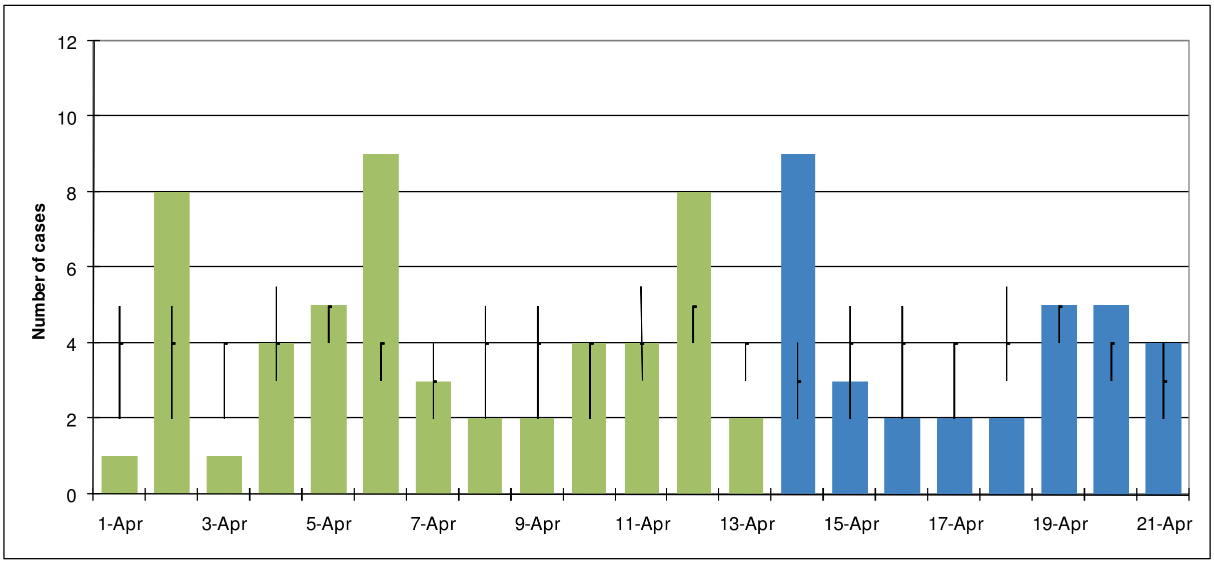


**Figure 3: Emergency medical dispatch cases with cardiovascular syndrome in Tyrol in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile.**

 

<u>Transport-related injuries</u>

In April 2010 (April 1st – 21st) 54 cases with traffic-related injuries were dispatched, on average 3 cases per day. During the same period in 2009 also 3 cases per day were registered, in total 53 cases. Figure 4 shows the daily number of patients with traffic-related injuries and as reference the median as well as the 25th and 75th percentile of cases with traffic-related injuries for the same weekday (Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st).

The daily number of cases with traffic-related injuries deviated before as well as during the volcanic ash cloud period on some days from the reference period in 2009. But on the weekend April 17th and 18th the number of cases with traffic-related injuries was the highest. In April 2010 the proportion of traffic-related injuries per overall number of cases per day was 3.6% on average. The proportion of traffic-related injuries on April 17th was 8.9% and 7.7% on April 18th.

However, **the stratified application of the detection algorithm (C1, C2, C3) on the daily proportions of cases with traffic-related injuries resulted in no aberrant signal of the C1, C2 and C3 algorithm.**

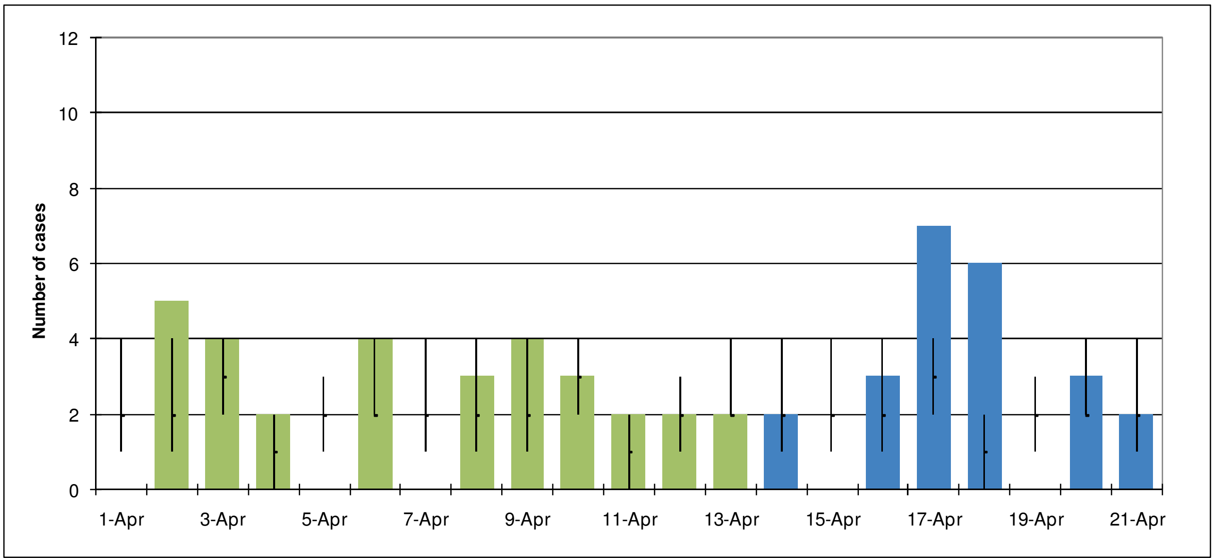


**Figure 4: Emergency medical dispatch cases with traffic-related injuries in Tyrol in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile.**

## 3.2 Spain: Autonomous Region of Cantabria

The case study in Spain is based on data from the **Emergency Department of the University Hospital in Santander** which serves a population of approx. 300,000 inhabitants of the Autonomous Region of Cantabria.

Data from April 2010 (April 1st – 19th) was available for data analysis. Of major interest was the data from April 14th (volcanic eruption) to the most recent available data (April 19th). Data from March, April and May 2009 was used as reference.

**Overall number of cases**

From April 1st to 19th, 2010 6,427 patients visited the emergency department of the hospital. For the same period in 2009 6,390 patients were registered.

Although the day-of-the-week effect in the Spanish data set is not that strong as in the Austrian data set a variation can be seen as well. Always on Sundays the frequency of visits is the lowest of the week while it is the highest on Mondays.

Due to this day-of-the-week variation figure 5 shows the overall number of emergency department patients in April 2010 and as reference the median as well as the 25th and 75th percentile of data from the same weekday (e.g. Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st).

**It can be seen that during the volcanic ash cloud period the number of visits at the emergency department of the University Hospital Santander did not exceed the 75th percentile of the respective weekdays in the reference period in 2009. Thus, the number of visits during the volcanic ash cloud period equalled the number of visits in the reference period 2009.**

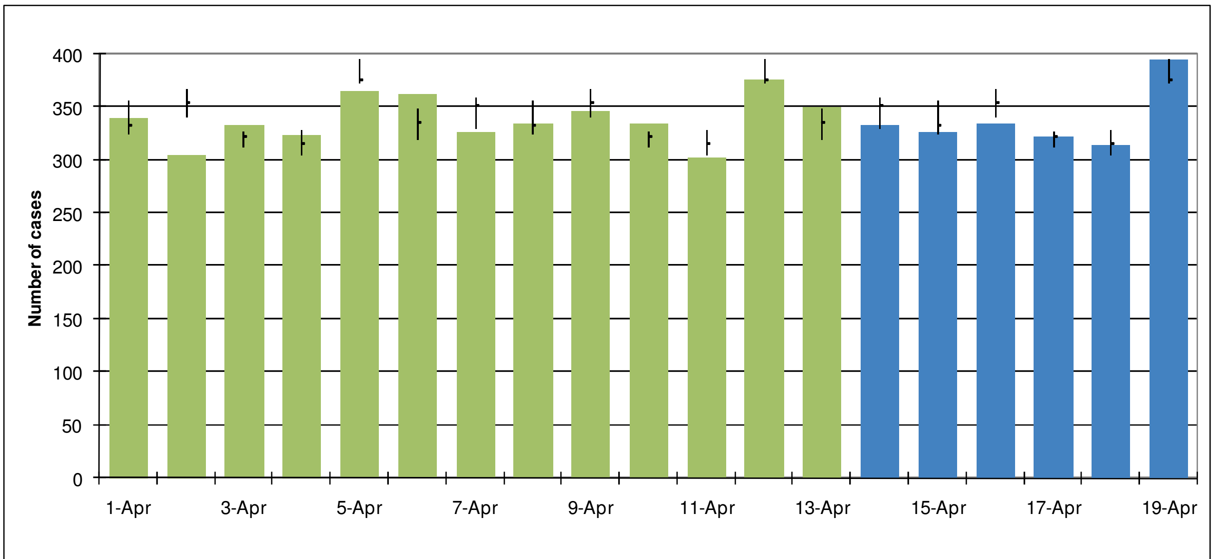


**Figure 5: Overall number of cases in the emergency department of the university hospital in Santander in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile.**

## Detection algorithm C1, C2, C3 - Overall demand

The C1, C2, C3 algorithm was applied on the overall number of emergency department visits per day. Since the day-of-the-week variation in the Spanish data set is not as strong as in the Austrian data set, the algorithm was applied unstratified and stratified (stratum 1: Sunday, stratum 2: Monday, stratum 3: Tuesday to Saturday). **During the period of the persistence of the volcanic ash cloud and the period for which data was available from the emergency department in Santander (April 14th -19th, 2010) no aberrations from the expected number of emergency department visits has been identified neither in the unstratified nor in the stratified analysis.**

## Descriptive analysis and detection algorithm C1, C2, C3 - Severity-specific analysis

In the Spanish implementation site no information on symptoms but on the severity of cases is provided (level A, B and C represent high severity, level D and E represent low severity cases). High and low severity case groups were analysed for aberrations during the period of interest in April 2010. Data for 2009 followed a deviant severity grouping and could therefore not be used as reference.

In April 2010 (April 1st – 19th) the percentage of the different severity case groups was varying over the whole month, mostly influenced by day-of-the-week effects (figure 6).

**The unstratified and stratified application of the detection algorithm C1, C2, C3 on the proportion of low and high severity cases per overall number of daily cases resulted in no alert during the volcanic ash cloud period.**

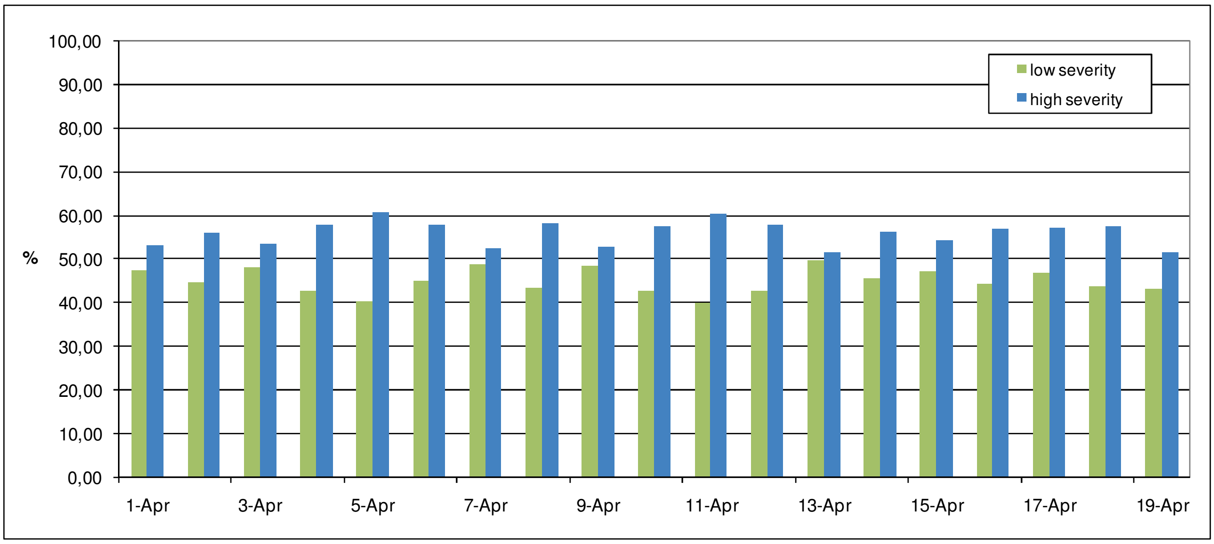


**Figure 6: Percentage of cases with high and low severity in the emergency department of the university hospital in Santander in April 2010.**

## 3.3 Germany: County of Goeppingen

The case study in Germany is based on data from the emergency physician service in the County of Goeppingen (255,807 inhabitants) which belongs to the federal state of Baden-Wuerttemberg. The data set consisted of patients treated by emergency physicians at the emergency scene.

Data from April 2010 (April 1st – 25th) was available for the data analysis. Of major interest was the data during the volcanic ash cloud period (April 14th April – 22nd). Data from March, April and May 2009 was used as reference.

### Overall number of cases

From April 1st to 25th, 2010 233 patients were treated in the emergency physician service in Goeppingen. For the same period in 2009 245 emergency cases were registered.

In this data set no daily variation was identified. In 2009 there were on average 10 cases per day irrespective of the day of the week. In 2010 a slight variation was identified with cases ranging from nine to eleven cases.

For a better overview figure 7 shows the overall number of emergency physician cases in April 2010 and as reference the median as well as the 25th and 75th percentile of data from the same weekday (e.g. Monday, Tuesday, etc.) in 2009 (reference period March 1st – May 31st).

**It can be seen that during the volcanic ash cloud period (April 14th – 22nd, 2010) the number of cases was on two occasions higher compared to the reference period in 2009. But these variations existed before the volcanic eruption in the data set.**

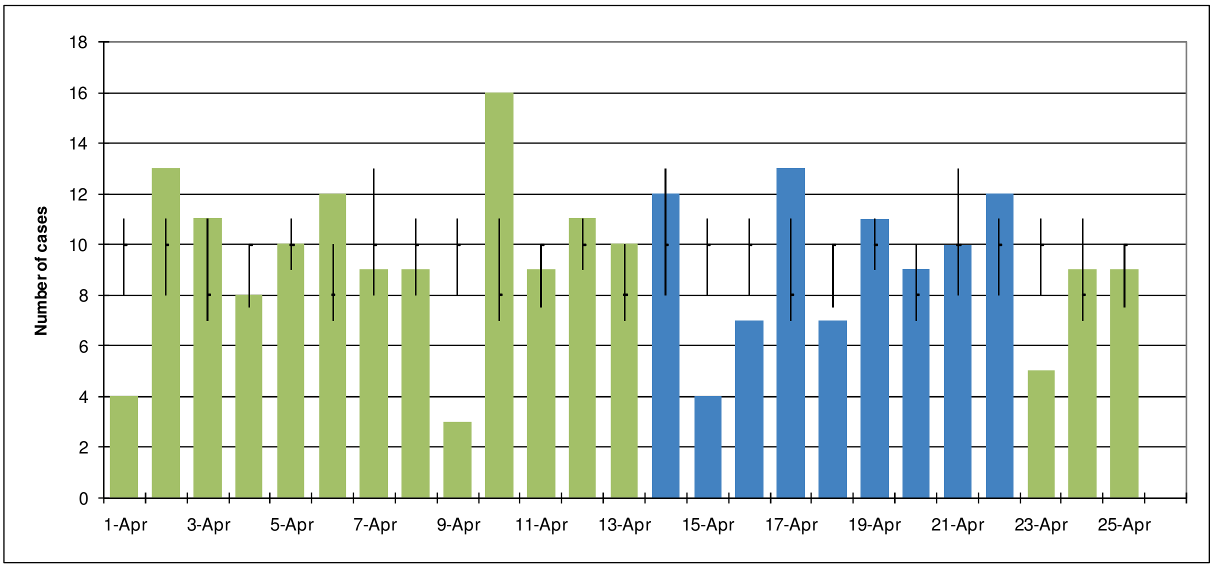


**Figure 7: Overall number of emergency physician cases in 2010. Lines related to the bars show the median of the same weekday for the reference period 2009 (March 1st – May 31st, 2009) and the 25th to 75th percentile.**

## Age distribution

The analysis of the age distribution of all cases showed a slight increase for almost all age groups during the period of the volcanic ash cloud compared to a similar period before the eruption (see table 3). **However, the number of cases for both periods did not differ significantly per age group (p>0.05[8]).**

| Period 2010 | N (%) < 1 year | N (%) 2-18 years | N (%) 19-69 years | N (%) > 70 years | Total |
|---|---|---|---|---|---|
| 14-4 to 21-4 | 2 (2.7%) | 6 (8.1%) | 32 (43.8%) | 33 (45.2%) | 73 |
| 6-4 to 13-4 | 0 (0%) | 4 (5.1%) | 41 (52.6%) | 33 (42.3%) | 78 |

**Table 3: Total number of cases per age group during the volcanic ash cloud period in comparison to a comparable period before the eruption**

## Detection algorithm C1, C2, C3 – Overall demand

The C1, C2, C3 algorithm was applied on the overall number of cases per day. Since there were no indications for day-of-the-week variation in the German data set, the algorithm was applied unstratified. **In April no signals occurred when applying C1, C2, C3 – there were no aberrations from the expected number of cases.**

## Descriptive analysis and detection algorithm C1, C2, C3 - Syndrome-specific analysis

In April 2009 (1st to 26th) ICD-10 codes were missing for 8.3% of the cases (N=21) and in 2010 ICD-10 codes were missing for 10.5% of the cases (N=25). These cases have been left in the data set for the detection algorithm analysis.

[8] Fisher Exact test for age group "< 1 year" and "2-18 years"; Pearson Chi-Square for age group "19-16 years" and "≥70 years"

Respiratory syndrome

In April 2010 (1st to 26th) 12 cases with respiratory syndrome were treated, on average 0.46 per day. During the same period in 2009 0.3 cases per day were treated, 8 cases in total.

Since in this data set variation in the daily number of patients treated by emergency physicians was not present the percentage of daily cases with respiratory syndrome is shown in figure 8 for April 2010 and for the same date in 2009. Patients with respiratory syndrome were not treated every day, the highest number of cases was registered 2010 before the ash cloud period. **The unstratified application of the detection algorithm C1, C2, C3 on the proportion of daily cases with respiratory syndrome per overall number of cases resulted in no aberrant signal during the volcanic ash cloud period.**

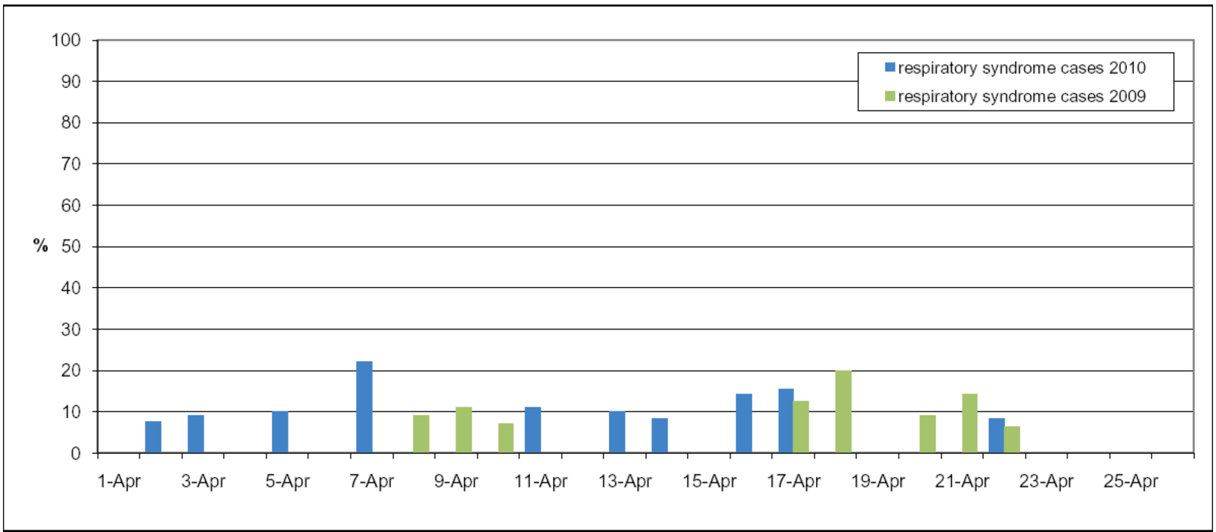


**Figure 8: Percentage of daily emergency physician cases in Goeppingen (Germany) with respiratory syndrome in April 2009 and 2010.**

Cardiovascular syndrome

In April 2010 (1st to 26th) the database contained 100 cases with cardiovascular syndrome, on average 3.9 cases per day. During the same period in 2009 4.3 cases per day were registered, in total 111 cases.

The percentage of daily cases with cardiovascular syndrome is shown in figure 9 for April 2010 and for the same date in 2009 since no day-of-the-week variation was identified in this data set. The highest number of cases was registered in 2010 before the ash cloud period. **The unstratified application of the detection algorithm C1, C2, C3 on the proportion of daily cases with cardiovascular syndrome per overall number of cases resulted in no aberrant signal during the volcanic ash cloud period.**

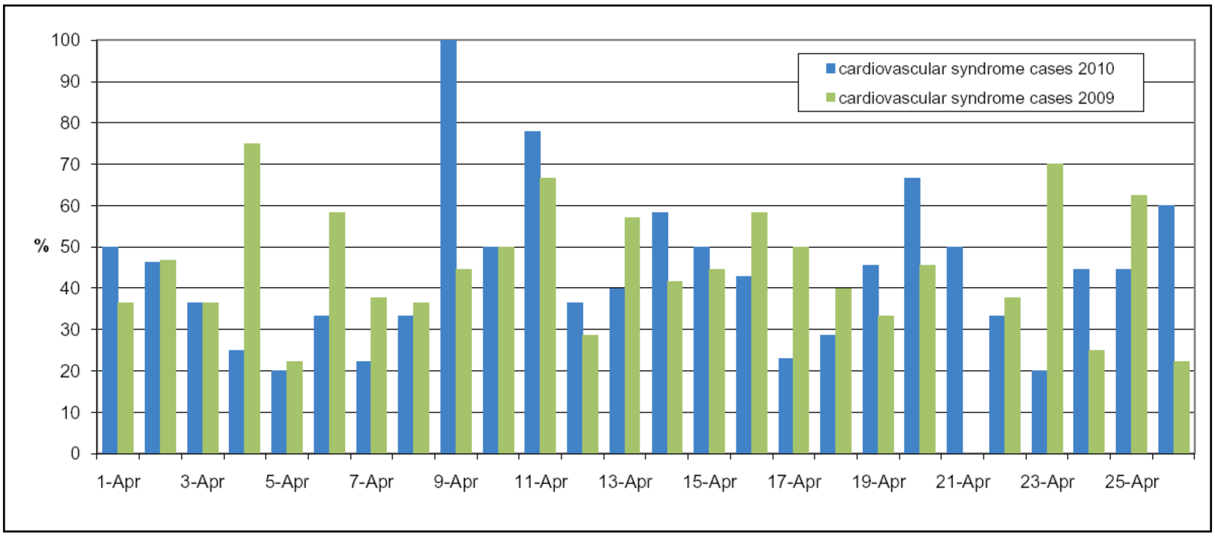


**Figure 9: Percentage of daily emergency physician cases in Goeppingen (Germany) with cardiovascular syndrome in April 2009 and 2010.**

# 4 Discussion & Conclusions

The SIDARTHa project group started immediately during week 16 to investigate if potential health effects during the volcanic ash cloud period (April 14th – 22nd, 2010) could be identified by the SIDARTHa pilot system. For the analysis emergency medical care data from three SIDARTHa implementation sites was used.

A descriptive analysis was performed on the overall and on the syndrome- or severity specific case volume. If available, the age distribution of the cases was examined. Furthermore, the detection algorithm C1, C2, C3 was applied to analyse if the daily number or the daily syndrome- or severity-specific proportion of cases deviated at least more than two/three standard deviations from baseline values.

It was shown that the SIDARTHa pilot system was able to be adapted immediately to investigate the near-real time data from different emergency medical care services in different European regions. This demonstrates the flexibility of syndromic surveillance systems to be used for ad-hoc surveillance after suddenly occurring events. After Hurricane Katrina 2005[9] or the 2005 London terrorist attacs[10] for example, syndromic surveillance systems were also setup or adjusted rapidly to be used for situational awareness in order to assure that no public health event (e.g., infectious disease outbreak, further bioterrorist event) was following the disasters and for general health monitoring of the health impact after the events.

In general, data from all three implementation sites showed no striking deviations in case volume as well as in the age distribution during the volcanic ash cloud period in comparison with the respective reference period. Also during the specific periods during which each region might have been exposed according to prognosis of MetOffice only one aberration was identified. Only on April 19th, 2010 there was an increase in the cases with respiratory syndrome in Tyrol (emergency medical dispatch data) which varied more than three standard deviations (signal C1, C2 and C3) from the baseline. Since syndromes like the respiratory syndrome could also occur due to other environmental hazards and a direct health impact of the volcanic ash cloud was not proven so far, further in-depth analysis of case characteristics is necessary. With the information available in the Tyrolean data set it could be identified that these cases had breathing problems which mainly influenced their speaking ability between breaths. The age distribution of patients with and without respiratory syndrome did not differ significantly. Furthermore, no spatial cluster of cases was identified.

Upon the detection of the aberration on April 19th, the dispatch centre Tyrol has tried to retrace the respiratory syndrome cases to identify the cause for the increase. One case was identified which might have been misinterpreted having a respiratory problem caused by trauma. But also when excluding this case from the C1, C2, C3 analysis the aberrant signal persists.

For a deeper understanding it would be necessary to also include the diagnosis made by the emergency physicians or at the emergency department, since these would contain more detailed disease-specific information than the information from the dispatch centre. Furthermore, environment-related information would be supportive for further interpretation of the relevance of the aberrant signal on April 19th, e.g. information on the pollen or the particulate matter-10-level.

This rapid assessment was rather descriptive and still exploratory: a direct link between the aberrant signal on April 19th in Tyrol and the volcanic ash cloud cannot be established. Other official bodies like the Scientific

[9] Murray KO, Kilborn C, DesVignes-Kendrick M, Koers E, Page V, Selwyn BJ, et al. Emerging disease syndromic surveillance for Hurricane Katrina evacuees seeking shelter in Houston's Astrodome and Reliant Park Complex. Public Health Rep. 2009 May-Jun;124(3):364-71.

[10] Smith GE, Cooper DL, Loveridge P, Chinemana F, Gerard E, Verlander N. A national syndromic surveillance system for England and Wales using calls to a telephone helpline. Euro Surveill. 2006;11(12):220-4.

Advisory Group of the World Health Organisation detected no direct exposure of the population with volcanic eruption-related air pollution and identified no health effects by national health surveillance systems.[11] The European Commission reported no health effects either. They argued that this might be due to the fact that the cloud of ash moved at a high altitude and spread over large areas.[12]

It cannot not be expected that the signal in Tyrol was related to the ash cloud. Despite this signal the SIDARTHa pilot system confirmed the official expectations and analyses by showing no deviations and signals in the other data sets.

The main limitation is the application of only one detection algorithm. Other algorithms might detect an aberration from the baseline that could provide further insight into the health impact of the volcanic ash cloud. The SIDARTHa pilot syndromic surveillance system currently applies next to C1, C2, C3 also the algorithms ARIMA and Holt Winters Smoothing which were not yet applied during this rapid assessment.

The SIDARTHa pilot syndromic surveillance system demonstrated its flexibility to be rapidly adjusted for investigating if there was any regional public health impact of the volcanic ash cloud covering Europe in April 2010. This rapid assessment provided a valuable test bed for the pilot system which enables the SIDARTHa consortium to further develop the surveillance system.

[11] World Health Organization. WHO/Europe expert group concludes Icelandic volcanic ash currently poses no threat to public health. http://www.euro.who.int/air/volcaniceruptionupdates/20100430_1 (accessed May 4th 2010)

[12] European Commission. DG Health and Consumers. Effects of the volcanic ash cloud. http://ec.europa.eu/dgs/health_consumer/dyna/consumervoice/create_cv.cfm?cv_id=638 (accessed May 4th 2010)

# Appendix 1 SIDARTHa syndrome definitions (AMPDS Codes; v12)

The syndrome is generated when one of the respective listed codes is mentioned for a case.

**Respiratory Syndrome**

Category 6 – Breathing Problems

| | |
|---|---|
| 6E1 | Ineffective breathing |
| 6D1 | Not alert |
| 6D2 | Difficulty speaking between breaths |
| 6D3 | Changing color |
| 6D4 | Clammy |
| 6C1 | Abnormal breathing |

In category 6 all codes can have the suffix A, for Asthma. These were also part of the case definition.

Category 26 – Sick Person

| | |
|---|---|
| 26C2 | Abnormal breathing |
| 26C26 | Sore throat (without difficulty breathing or swallowing) |

**Cardiocvascular Syndrome**

Category 10 – Chest Pain

| | |
|---|---|
| 10D1 | Not alert |
| 10D2 | Difficulty speaking between breaths |
| 10D3 | Changing colour |
| 10D4 | Clammy |
| 10C1 | Abnormal breathing |
| 10C2 | heart attack or angina history |
| 10C4 | Breathing normally > 35 |

Category 19 – Heart problems / A.I.C.D.

| | |
|---|---|
| 19D1 | Not alert |
| 19D2 | Difficulty speaking between breaths |
| 19D3 | Changing colour |
| 19D4 | Clammy |
| 19D5 | Just resuscitated and/or defibrillated (external) |
| 19C1 | Firing of A.I.C.D. |
| 19C2 | Abnormal breathing |
| 19C3 | Chest pain > 35 |
| 19C4 | Cardiac history |
| 19C6 | Heart rate < 50 bpm or > 130 bpm (without priority symptoms) |
| 19C7 | Unknown status/ other codes not applicable |
| 19A1 | Heart rate > 50 bpm and <130 bpm (without priority symptoms) |
| 19A2 | Chest pain <35 (without priority symptoms) |

### Traffic-related injuries

Category 29 – Traffic-/transportation incidents

| | |
|---|---|
| 29D1 | Major incident (a through f) |
| 29D2 | High mechanism (k through s) |
| 29D3 | Hazmat |
| 29D4 | Pinned (trapped) victim |
| 29D5 | Not alert |
| 29B1 | Injuries |
| 29B2 | Serious hemorraghe |
| 29B3 | Other hazards |
| 29B4 | Unknown status/other codes not applicable |
| 29A1 | 1st party caller with injury to not dangerous body area |
| 29Ω1 | No injuries (confirmed) |

Add-ons:

| | |
|---|---|
| 29D1 | a – aircraft |
| | b – bus |
| | c – subway/metro |
| | d – train |
| | e – watercraft |
| | f – multi-vehicle (≥10) pile-up |
| 29D2 | k – all-terrain/snowmobile |
| | l – auto-bysicle/motorcycle |
| | m – auto-pedestrian |
| | n – ejection |
| | o – personal watercraft |
| | p – rollovers |
| | q – vehicle off bridge/height |
| | r – possible death at scene |
| | s – sinking vehicle |
| other add-ons: | M = multiple patients |
| | U = unknown number of patients |
| | A = multiple patients and additional response required |
| | X = unknown number of patients and additional response required |

# Appendix 2 SIDARTHa syndrome definitions (ICD 10)

The syndrome is generated when one of the respective listed codes is mentioned as chief complaint for a case.

**Respiratory syndrome**

| | |
|---|---|
| J00 | Acute nasopharyngitis [common cold] |
| J02 | Acute pharyngitis (includes sore throat) |
| J04 | Acute laryngitis and tracheitis |
| J05.0 | Acute obstructive laryngitis [croup] |
| J05.1 | Acute epiglottitis |
| J06 | Acute upper respiratory infections of multiple and unspecified sites |
| J10 | Influenza due to other identified influenza virus |
| J11 | Influenza, virus not identified |
| J12 | Viral pneumonia, not elsewhere classified |
| J13 | Pneumonia due to Streptococcus pneumoniae |
| J14 | Pneumonia due to Haemophilus influenzae |
| J15 | Bacterial pneumonia, not elsewhere classified |
| J16 | Pneumonia due to other infectious organisms, not elsewhere classified |
| J17 | Pneumonia in diseases classified elsewhere |
| J18 | Pneumonia, organism unspecified |
| J20 | Acute bronchitis |
| J21 | Acute bronchiolitis |
| J22 | Unspecified acute lower respiratory infection |
| J36 | Peritonsillar abscess |
| J39 | Other diseases of upper respiratory tract |
| J44.0 | Chronic obstructive pulmonary disease with acute lower respiratory infection |
| J44.1 | Chronic obstructive pulmonary disease with acute exacerbation, unspecified |
| J46 | Status asthmaticus (acute exacerbation of asthma) |
| J68.2 | Upper respiratory inflammation due to chemicals, gases, fumes and vapours, not elsewhere classified |
| R05 | Cough |
| R06.0 | Dyspnoea (Orthopnoea, Shortness of breath) |
| R06.1 | Stridor |
| R06.2 | Wheezing |
| R50 | Fever of other and unknown origin |

**Cardiovascular syndrome**

| | |
|---|---|
| I00-I99 | Diseases of the circulatory system |

# Appendix 3 Detection Algorithm C1, C2, C3

The C1, C2, C3 detection methods standardise each observation by using a moving sample average and sample standard deviation. The C1 algorithm uses seven previous days to calculate the sample average and sample standard deviation.

$$C_1(t) = \frac{Y(t) - \overline{Y}_1(t)}{S_1(t)}$$

$$\overline{Y}_1(t) = \frac{1}{7}\sum_{i=t-1}^{t-7} Y(i) \quad \text{and} \quad S_1^2(t) = \frac{1}{6}\sum_{i=t-1}^{t-7}\left[Y(i) - \overline{Y}(i)\right]^2$$

The threshold of the C1 algorithm is fixed and alerts when the C1 statistic exceeds a value of three. This is correspondent to a value being higher than three sample standard deviations above the sample mean.

The C2 algorithm includes also seven days for calculation but inserts a 2-day lag to avoid influences of an upswing of a probable outbreak. Therefore, the observations nine to three days before the day of interest are included.

$$C_2(t) = \frac{Y(t) - \overline{Y_3}(t)}{S_3(t)}$$

$$\overline{Y}_3(t) = \frac{1}{7}\sum_{i=t-3}^{t-9} Y(i) \quad \text{and} \quad S_3^2(t) = \frac{1}{6}\sum_{i=t-3}^{t-9}\left[Y(i) - \overline{Y_3}(i)\right]^2$$

For the C2 algorithm the same threshold as for the C1 algorithm applies. C2 statistics >3 exceed the expected values (1).

The C3 method uses the C2 statistic from the current day and two days prior to the current observation.

$$C_3(t) = \sum_{i=t}^{t-2} \max\left[0, C_2(i) - 1\right]$$

Values > 2 should be judged as alerting signals.

In medical emergency data different patterns of case occurrence are known. In some data sets there are for example more cases during weekdays than on weekends and also public holidays influence the number of emergency cases. Since in C1, C2 and C3 the baseline is build by the number of cases which occurred in the same season (7 to 9 days before the current observation) seasonal variations are taken indirectly into account[13]. Tokars and colleagues modified the algorithms to be able to take also the day-of-week into account which might increases sensitivity[14]. Therefore the detection methodology will be used in two different ways:

- Taking the last seven to nine days into account as it is described in Fricker RD[15].
- Stratifying baseline data in e.g. weekdays and weekend days. Depending on the day of the current observation, weekdays or weekend days are used to calculate the sample mean and standard deviation. This stratification is known as W2 algorithm.

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[13] Hutwagner LC, Thompson WW, Seeman GM, Treadwell T. A simulation model for assessing aberration detection methods used in public health surveillance for systems with limited baselines. Stat Med. 2005 Feb 28;24(4):543-50.
[14] Tokars JI, Burkom H, Xing J, English R, Bloom S, Cox K, et al. Enhancing time-series detection algorithms for automated biosurveillance. Emerg Infect Dis. 2009 Apr;15(4):533-9.
[15] Fricker RD, Jr., Hegler BL, Dunfee DA. Comparing syndromic surveillance detection methods: EARS' versus a CUSUM-based methodology. Stat Med. 2008 Jul 30;27(17):3407-29.