



## Forensic Pathology

## Trends in forensic autopsy rates in Central Norway during the period 2007–2017: Can media attention impact autopsy practices?

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## ABSTRACT

The knowledge base regarding the frequency of forensic autopsies is limited. A Norwegian study investigated the practice of forensic autopsies in two neighbouring counties in Central Norway, Sør-Trøndelag and Nord-Trøndelag, in 2007–2009. This study revealed low autopsy rates for several manners of death and substantial regional differences. In 2013 the findings from this study received attention in Norwegian national media. The aim of our study was to evaluate the impact of this media attention by investigating the forensic autopsy rates in the same two counties over the time period 2007–2017, and, in particular, comparing the autopsy rates before and after the media attention in 2013. Data was retrieved anonymously from the Norwegian Cause of Death Registry, and analysed using the Chi square test. We found that the media attention in 2013 may have had a temporary effect on the forensic autopsy rates in Nord-Trøndelag, but overall there has been no noteworthy or lasting impact in either of the counties, and regional differences remain. The total forensic autopsy rate for unnatural deaths has declined from 40% to 30% over the time period 2007–2017, which is neither adequate nor in accordance with national legislation.

## 1. Introduction

Autopsies can provide valuable information about the cause of death, especially when the cause of death is unclear or suspicious. Despite medical advancements, autopsy is still an important corrective to clinical diagnosis, and an adequate autopsy rate is necessary to secure the quality and validity of the cause of death statistics [1–6]. Autopsy can clarify how and why unnatural deaths occur, and hence be used to prevent similar cases in the future. Autopsy is also important for legal prosecution, insurance settlements, and information to the bereaved.

In Norway, medical doctors request clinical autopsies, whereas the police request forensic autopsies when the cause of death is suspected to be unnatural. According to Norwegian legislation, a forensic autopsy is mandatory in cases where a criminal act is suspected, the deceased is <18 years old, or the corpse is unidentifiable [7]. In cases where the cause of death is uncertain, is thought to be accidental, a result of suicide or incorrect medical treatment, a forensic autopsy is not mandatory, but should usually be carried out according to the prosecution instructions [7].

The frequency of clinical autopsies has declined in various countries over the last decades [8–12], to the concern of pathologists around the world [13–17]. However, the knowledge base regarding the frequency

of forensic autopsies is limited. A Norwegian study investigated the practice of forensic autopsies in two neighbouring counties in Central Norway, Sør-Trøndelag and Nord-Trøndelag, in 2007–2009 [18]. They found that forensic autopsy rates varied with regard to manner of death, police county, sex, and age, and that the autopsy rate was alarmingly low for some causes of death. Another important finding was substantial regional differences between the two counties in requesting forensic autopsies, despite national legislation. During 2013 the findings in the study by Frost et al. received attention in Norwegian national media. They addressed the need for increased and standardised practices with regard to the request for forensic autopsy, in accordance with the Norwegian legislation. The aim of our work was to evaluate the impact of the media attention, by investigating the forensic autopsy rates in the same two counties in Central Norway over the period 2007–2017, and, in particular, comparing the autopsy rates before and after the media attention in 2013.

## 2. Materials and methods

This is an observational study of the forensic autopsy rates in the two counties Sør-Trøndelag and Nord-Trøndelag (population 320,000 and 138,000 in 2017, respectively [19]) in Central Norway in 2007–2017.

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## 2.1. Data collection

Data for the period 2010–2017 were retrieved from the Norwegian Cause of Death Registry. The following data were collected: absolute number of deaths and forensic autopsies in Sør-Trøndelag and Nord-Trøndelag, manner of death, sex and age groups. For the years 2007–2009 the same data were retrieved from the previously published study by Frost et al. [18].

## 2.2. Death classification

The Norwegian Cause of Death Registry is based on the World Health Organisation's (WHO) International Classification of Diseases (ICD-10) codes in death certificates and autopsy reports [20]. Manner of death is in this work organised into the categories natural and unnatural. Unnatural deaths are further categorised into accidents, suicides, and homicides. Accidents are subcategorised into road traffic accidents (including pedestrians, pedal cyclists, motorcycle riders, and drivers and passengers of cars and other vehicles), fall accidents (including high and low energy falls, but fracture of the neck of the femur has since 2005 been classified as unspecified accident if not otherwise specified in the death certificate), accidental poisonings (including accidental overdose of drug, poisonings, wrong drug taken or given in error, drug taken inadvertently and without intent to harm), and other accidents (including drowning, exposure to flames, smoke and electric current). Suicide includes deaths by intentional self-inflicted injury or poisoning. Homicide includes intentional murder as well as death as a result of injury inflicted by another person with intent to injure.

The forensic autopsy can also conclude that the cause of death was natural. Natural death comprises deaths due to diseases and ill-defined and unknown causes of mortality such as sudden infant death syndrome, sudden unexplained death in adults and deaths where no cause could be determined.

## 2.3. Statistics

A forensic autopsy rate is defined as the number of performed forensic autopsies divided by the number of deaths within a category. The total number of deaths used to calculate the total autopsy rate includes both natural and unnatural deaths.

The data received from The Norwegian Cause of Death Registry were divided into four time periods; two periods before (2007–2009 and 2010–2012) and two periods after (2013–2015 and 2016–2017) the media attention in early 2013. For that reason, all autopsy rates are presented as averages in the given time periods, and did therefore not allow

investigations of trends year by year.

The trends in autopsy rates were calculated both for the total number of forensic autopsies and the different manners of death, sex and age groups.

Chi square test was used to test for differences in proportion of autopsied cases across time periods (2007–2009, 2010–2012, 2013–2015, 2016–2017) in total and pairwise (one period versus the previous one). A P-value of  $< 0.05$  was set to determine statistical significance.

## 2.4. Ethics

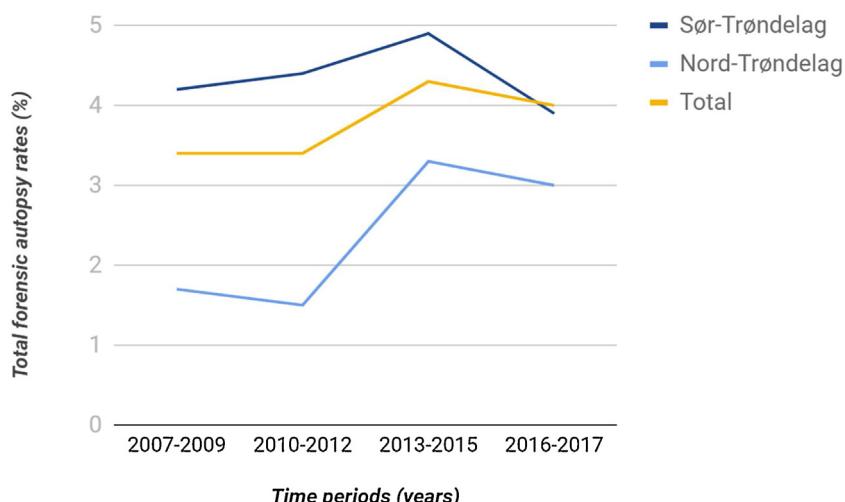
All data from the Norwegian Cause of Death Registry was handed out anonymously. Hence, there was no need for an approval from the Regional Committee for Medical and Health Research Ethics. This was explicitly declared both by the Norwegian Cause of Death Registry and the Regional Committee for Medical and Health Research Ethics.

## 3. Results

During the period 2007–2017 a total of 39,276 persons died in Central Norway, 26,305 in Sør-Trøndelag and 12,971 in Nord-Trøndelag. A total of 1444 deaths were subjected to a forensic autopsy, 1147 from Sør-Trøndelag and 297 from Nord-Trøndelag. Of the 1444 autopsied cases 604 (42 %) were classified as natural deaths and 504 (35 %) as accidents after autopsy. Out of 473 suicide deaths 313 (66 %) were subjected to forensic autopsy. Out of 25 homicides 23 (92 %) were subjected to forensic autopsy. During the whole period 52 % of the deaths were female, 1.6 % were  $< 30$  years, 7.8 % between 30–59 years and 90.6 %  $> 59$  years old. Of the total forensic autopsy cases 73 % were male, 17 % were  $< 30$  years, 48 % between 30–59 years and 35 %  $< 59$  years. Of the total number of deaths (autopsied and not) 5.6 % were classified as unnatural. Of all deaths that were presumed to be unnatural, 51 % were subjected to forensic autopsy.

The total forensic autopsy rates for Sør-Trøndelag, Nord-Trøndelag and both counties combined for the four time periods (2007–2009, 2010–2012, 2013–2015 and 2016–2017) are graphically displayed in Fig. 1, and categorised with regard to manner of death, sex and age groups in Table 1. The total forensic autopsy rate varied between 3.4 % and 4.3 %. The increase between the second and third period and the decline between the third and fourth period proved to be statistically significant ( $p = 0.001$  and  $p = 0.019$ , respectively). The overall changes through the time periods were also significant ( $p = 0.001$ ).

In Sør-Trøndelag the forensic autopsy rate varied between 3.9 % and 4.9 %. The decrease between the third and fourth period was significant ( $p = 0.015$ ), but no other changes or the overall changes through the four



**Fig. 1.** Total forensic autopsy rates (%) in Central Norway 2007–2009, 2010–2012, 2013–2015 and 2016–2017.

**Table 1**

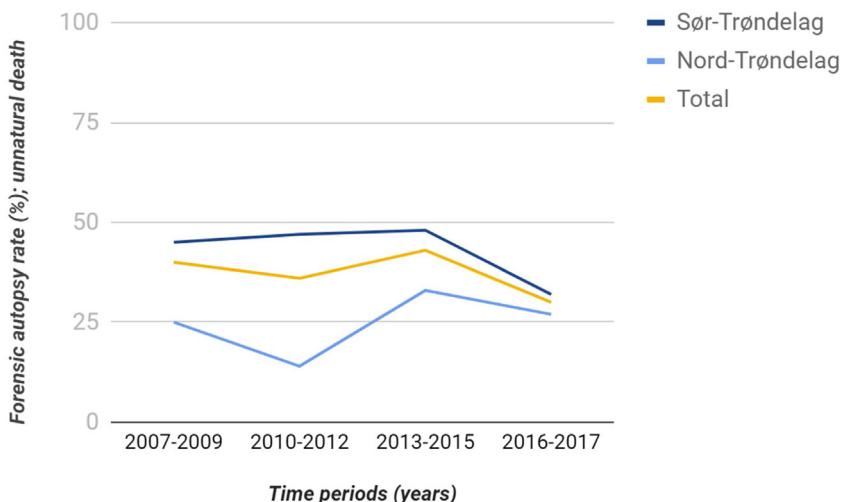
Forensic autopsy rates in Central Norway 2007–2009, 2010–2012, 2013–2015 and 2016–2017 by manner of death, sex and age.

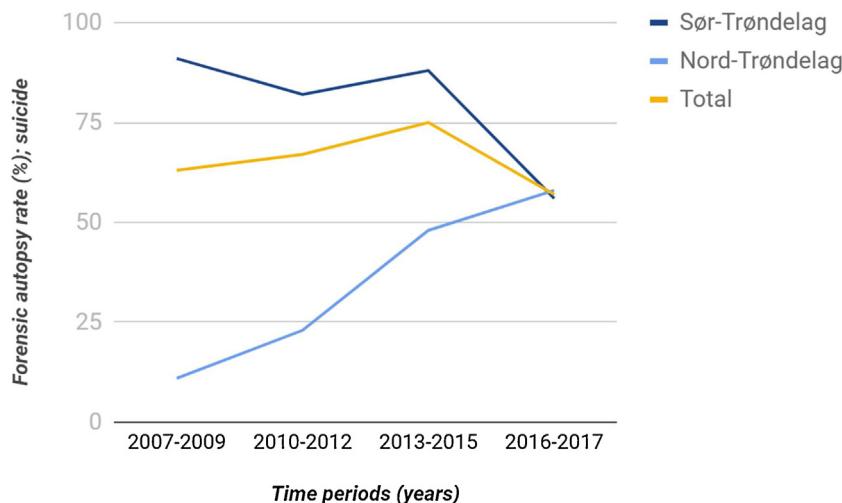
	Sør-Trøndelag				Nord-Trøndelag				Total			
	2007– 2009	2010– 2012	2013– 2015	2016– 2017	2007– 2009	2010– 2012	2013– 2015	2016– 2017	2007– 2009	2010– 2012	2013– 2015	2016– 2017
	%	%	%	%	%	%	%	%	%	%	%	%
<b>Manner of death</b>												
Natural death	1.6	2.0	2.0	2.3	0.6	0.8	1.5	1.4	1.2	1.6	1.8	2.0
Unnatural death	45	47	48	32	25	14	33	27	40	36	43	30
Accidents	35	35	35	22	28	12	27	19	33	27	33	21
Accidental poisoning	83	98	89	46	88	46	91	58	84	87	89	49
Road traffic accident	67	75	66	55	46	36	50	75	57	62	61	60
Accidental fall	10	8.8	6.3	5.2	17	4.3	10	4.3	12	7.1	7.4	4.8
Other accidents	25	20	23	18	10	8.0	22	13	21	15	23	16
Suicide	91	82	88	56	11	23	48	58	63	67	75	57
Homicide	100	100	75	67	100	100	100	100	100	100	83	75
<b>Sex</b>												
Male	6.6	6.4	7.3	6.1	2.5	2.4	4.9	4.6	5.2	5.1	6.5	5.6
Natural death	2.5	3.1	2.9	3.7	1.0	1.3	2.5	2.4	2.0	2.5	2.7	3.3
Unnatural death	59	56	60	36	28	20	42	33	50	44	55	35
Female	2.0	2.5	2.5	1.9	1.0	0.6	1.7	1.4	1.6	1.9	2.2	1.8
Natural death	0.7	1.0	1.2	1.0	0.2	0.3	0.6	0.5	0.6	0.7	1.0	0.8
Unnatural death	27	35	29	25	21	7.1	22	19	25	26	27	22
<b>Age</b>												
< 30 years	39	43	49	20	33	45	42	35	38	44	48	23
Natural death	12	15	18	5.0	27	50	29	0.0	15	22	21	4.5
Unnatural death	89	83	84	47	39	40	67	55	74	71	81	49
30–59 years	26	25	27	21	15	8.0	22	23	23	20	25	21
Natural death	11	10	11	11	3.6	2.6	11	11	9.2	8.3	11	11
Unnatural death	84	88	85	58	59	39	62	71	76	77	78	61
> 59 years	1.4	1.6	2.0	2.0	0.3	0.6	1.5	1.3	1.0	1.3	1.8	1.8
Natural death	0.6	1.1	1.1	1.5	0.2	0.4	0.8	0.9	0.5	0.9	1.0	1.3
Unnatural death	19	16	22	14	4.2	5.0	18	11	15	12	21	13
<b>Total</b>	<b>4.2</b>	<b>4.4</b>	<b>4.9</b>	<b>3.9</b>	<b>1.7</b>	<b>1.5</b>	<b>3.3</b>	<b>2.9</b>	<b>3.4</b>	<b>3.4</b>	<b>4.3</b>	<b>3.6</b>

periods proved to be significant.

In Nord-Trøndelag the total autopsy rate varied between 1.5 % and 3.3 %. The increase between the second and third period, as well as the overall changes, proved to be statistically significant (both  $p < 0.001$ ).The forensic autopsy rates for unnatural deaths are graphically displayed in Fig. 2. The total forensic autopsy rate (both counties combined) for unnatural death varied between 30 % and 43 %. The increase between the second and third period ( $p = 0.011$ ), the declinebetween the third and fourth period ( $p < 0.001$ ) and the overall changes over time ( $p < 0.001$ ) were significant.In Sør-Trøndelag the forensic autopsy rate for unnatural deaths varied between 32 % and 48 %. Between the third and fourth period there was a decline that proved to be significant ( $p < 0.001$ ). The overall changes over time were also significant ( $p < 0.001$ ).

In Nord-Trøndelag the autopsy rate for unnatural death varied between 14 % and 33 %. There was a significant decline from the first to

**Fig. 2.** Forensic autopsy rates (%) for unnatural deaths in Central Norway 2007–2009, 2010–2012, 2013–2015 and 2016–2017.



**Fig. 3.** Forensic autopsy rates (%) for suicides in Central Norway 2007–2009, 2010–2012, 2013–2015 and 2016–2017.

the second period ( $p = 0.011$ ) followed by a significant increase from the second to third period ( $p < 0.001$ ). The overall changes over the time periods were also significant ( $p < 0.001$ ).

The forensic autopsy rates for suicides are shown in Fig. 3. The total forensic autopsy rate for suicides varied between 57 % and 75 %. The total rate for suicides increased slightly until the third time period where there was a marked decrease that proved to be statistically significant ( $p = 0.003$ ). The overall changes for the total rate over time were also significant ( $p = 0.026$ ).

For suicides the autopsy rate declined from 91 % to 56 % in Sør-Trøndelag from the first to the last period, and the biggest decline occurred between the two last periods. This decrease between the third and fourth time period, as well as the overall changes over time, were statistically significant ( $p < 0.001$  for both).

In Nord-Trøndelag the rate for suicides steadily increased from 11 % to 58 %. The increase between the second and the third period was statistically significant when the periods were compared pairwise ( $p = 0.023$ ). The overall autopsy increase for suicides in Nord-Trøndelag was significant ( $p < 0.001$ ).

#### 4. Discussion

The total autopsy rates (both counties combined) for different manners of death have been relatively unchanged during the first three time periods. There were small increases between the time periods 2010–2012 and 2013–2015 in all categories except for homicides. This development stems from Nord-Trøndelag where the rates increased notably for all manners of death between these two periods. Based on these observations, the media attention in 2013 may have had an impact on the forensic autopsy rates in Nord-Trøndelag. Nord-Trøndelag was also the county with the lowest autopsy rates in the previous study and thus had the largest incentive to improve practices. However, between the last two time periods (2013–2015 and 2016–2017) the total autopsy rates (both counties combined) declined again for all categories of unnatural deaths. This mainly stems from the observed declines in all categories of unnatural deaths in Sør-Trøndelag, but also in several categories in Nord-Trøndelag. Thus, there are no certain implications that the media attention had any impact in Sør-Trøndelag, and the possible effect in Nord-Trøndelag appears to be transient. Furthermore, in some categories the trends are opposite in the two counties, and large regional differences in autopsy practices remain. Our reinvestigation of the forensic autopsy rates therefore gives no clear indication that the awareness triggered by the earlier study by Frost et al. and the media attention that followed made any noteworthy or lasting impact.

There have been statistically significant changes in the total forensic autopsy rate for both counties combined. However, this total rate is based on all deaths, including natural deaths, which is the dominating manner of death (94 %). In this fairly large population, small changes in the rate can be of statistical significance, although not necessarily of clinical relevance. Overall, the total forensic autopsy rate has been relatively stable over the years 2007–2017, due to a stable autopsy rate for natural deaths. On the other hand, the total forensic autopsy rate for unnatural deaths in both counties combined has decreased from 40 % to 30 % over this time span. Of all deaths suspected to be unnatural during the whole period 2007–2017, only 51 % were subject to forensic autopsy. This indicates low compliance with Norwegian legislation which in practice instructs all unnatural deaths to be autopsied. Also, the fact that the rate has decreased from an already low and arguably inadequate level is concerning.

In January 2016 the two police districts Sør-Trøndelag and Nord-Trøndelag were merged into one. Accordingly, any observed differences in autopsy practices between the two counties after that should not be attributed to different practices or interpretations of the law. Interestingly, the merge of the two police districts coincides with the mentioned decline in autopsy rate for all categories of unnatural deaths between the two last time periods in Sør-Trøndelag and for several categories in Nord-Trøndelag. Within some categories the autopsy rates in the two counties became more similar (e.g. accidental poisonings and suicides), but substantial regional differences still remained in others (e.g. for road traffic accidents and homicides). The reason for this is not clear, and calls for closer scrutiny. One explanation may be continued practical and/or economic considerations related to the geographical location of the deaths.

One of the main findings in the study by Frost et al. was the discrepancy between Sør-Trøndelag and Nord-Trøndelag in the forensic autopsy rate for suicides, with respective rates of 91 % and 11 % in 2007–2009. It was questioned how the differences could be so large with the same legislation. The two counties have since had an opposite development (Fig. 3), and in 2016–2017 both counties had forensic autopsy rates just below 60 % for suicides. A low autopsy rate may be related to a lower detected suicide prevalence, which in turn may affect the validity of suicide mortality statistics [21]. Findings from several countries suggest that this manner of death in general is under-reported [22], which emphasizes the need for a high forensic autopsy rate. It should also raise concern that in nearly half of the cases where the manner of death is suspected to be suicide, it is concluded without an autopsy. If incorrectly categorised, we may fail to detect accidents or, more important, homicides.

Frost et al. found low and variable forensic autopsy rates for road traffic accidents [18]. This supported findings in an earlier study on road traffic accidents in Central Norway [23]. The opposite trends in Sør-Trøndelag and Nord-Trøndelag found in our material keep the total rate (both counties combined) at a relatively stable level around 60 %, which is in accordance with the average in the rest of Norway [24], but, in our opinion, too low. In February 2020 the Norwegian Parliament approved a change in the law to instruct that all road traffic fatalities shall be subject to a forensic autopsy. This is important because a forensic autopsy might uncover information about the accident that cannot be discovered otherwise, and is necessary in order to form specific and effective preventive interventions.

For accidents the autopsy rates decreased in both counties between the two last investigated time periods, particularly for the subcategory accidental poisonings. The total autopsy rate (both counties combined) for accidental poisonings in 2016–2017 was below 50 %. In Norway, toxicological screening is routinely conducted in all forensic autopsy cases. Especially for this subcategory the impact of drugs and poisons for the cause of death is important to establish. Without the performance of an autopsy, this information is in practice lost.

During the observed 11-year-period 2 of the 25 cases classified as homicides were not subject to a forensic autopsy. Why these cases were not autopsied is unknown due to the anonymised data, but the law specifically states that a forensic autopsy should be performed in all cases where the death is suspected to be caused by a criminal act. Thus it is surprising that the autopsy frequency is not 100 %.

Even though forensic autopsies are performed to investigate possible criminal acts, they may also be of value in instances where no incriminating evidence is indicated. An autopsy can provide useful information about the death mechanisms in all deaths, both natural and unnatural, which can be utilised in preventive endeavours. Correct cause of death statistics is important in all categories of death. The trends, rates and regional differences observed in this work clearly indicate that awareness alone is not sufficient, and that greater efforts to increase and standardise forensic autopsy practices are warranted. For road traffic accidents a change in the legislation to demand that all fatalities are autopsied has been implemented. It can be argued that this should be applied to all types of unnatural deaths. This could be a way to achieve adequate forensic autopsy rates nationally and eliminate regional differences that are due to non-medical causes such as different interpretations of the law and economic considerations.

## 5. Conclusions

The media attention that followed the study by Frost et al. in 2013 may have had a temporary effect on comparatively low forensic autopsy rates in Nord-Trøndelag, but overall no noteworthy or lasting impact was observed. The total forensic autopsy rates in the neighbouring counties Sør-Trøndelag and Nord-Trøndelag appear relatively stable over the time period 2007–2017. However, the rate has only been stable for natural deaths, and the rate for unnatural deaths has declined from 40 % to a deplorable 30 %. Within some of the selected categories the trends have been opposite in the two counties. In our opinion, a total forensic autopsy rate for unnatural deaths at 30 % is neither adequate nor in accordance with the national legislation.

## Declaration of Competing Interest

The authors report no declarations of interest.

## Transparency document

The Transparency document associated with this article can be found in the online version.

## CRediT authorship contribution statement

**Martine Ulvik:** Investigation, Formal analysis, Visualization, Writing - original draft. **Nina S. Bratsberg:** Investigation, Formal analysis, Visualization, Writing - original draft. **Ivar S. Nordrum:** Conceptualization, Methodology, Supervision, Writing - review & editing. **Joachim Frost:** Conceptualization, Methodology, Supervision, Writing - review & editing.

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