Chapter 1

Introduction

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According to the World Health Organization (WHO) annually there are 360,000 accidental drownings worldwide.[1] According to data from the Central Bureau of Statistics in the Netherlands, over the past five years in total nearly 1000 people have drowned (see Figure 1.1).[2] This comes to about 200 drowning cases per year. The number of intentional drownings that occur in the Netherlands is higher than the number of accidental drownings.

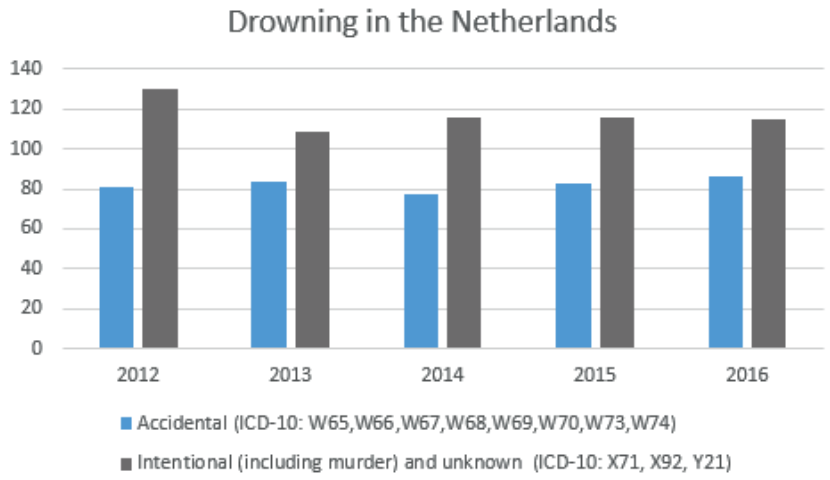

Figure 1.1 Drowning in the Netherlands according to the CBS.

The following international definition of drowning was adopted at the World Conference on Drowning in Amsterdam in 2002.[3]

"Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid"

According to this definition, drowning does not necessarily lead to death. There are no exact data available on the number of non-fatal drownings, but it is probable that this number is far greater than the number of fatal drownings. This publication focuses particularly on fatal drownings.

In the Netherlands an investigation is carried out to determine the cause of death when there is suspicion that the person has not died naturally (for example, people who are found in the water). This is initially performed by a forensic doctor and detectives. A total of 147,134 people died in the Netherlands in 2015.[4] A non-natural death (excluding euthanasia) was established in the post-mortem examination for 7,253 of these.[5] Only 279 (1.9%) of these non-natural death cases went on to have a forensic autopsy at the Netherlands Forensic Institute (NFI).[6]
In the Dutch system, if the investigation of the forensic doctor and detectives gives no concrete evidence of a crime, the case is usually not considered for a forensic autopsy. This is worrisome because it could allow homicides to be missed. The report of the Dutch Forensic Institute (NFI), "The post-mortem examination and autopsy considered", which was published in 2016, has calculated that due to the decreasing number of forensic autopsies, approximately 23 more deadly crimes were missed in 2015 compared to 10 years earlier.[6] To avoid missing crimes, it is important that the cause of death is determined for bodies found in the water. This is because it is possible that the body was left in the water after a crime in the presumption that it will not be found anymore.

Although drowning is likely to be the diagnosis when a body is found in the water, this cannot be determined based on this fact alone. For bodies found in the water, generally one of the following scenarios could have played out[7]:

1. Died from drowning or other immersion effects (accidental or intentional)
2. Died in the water but not drowned (e.g. heart attack during swimming)
3. Ended up in water post-mortem (e.g. car accident)
4. Placed in water post-mortem (e.g. murder)

Despite the fact that much scientific research has been conducted, there is no test available that can determine with certainty that drowning or immersion was the cause of death. This scientific research has looked at, among other things, the value of post-mortem radiology, diatoms, microbiological research, pulmonary surfactant-associated protein A (SP-A) and hemodilution /concentration. However, these tests are not strong enough to indicate or rule out a death due to drowning.[8-19]

The diagnosis of drowning can be most accurately determined for individuals who have died in the water, and for whom a comprehensive forensic autopsy cannot find any alternative explanation for death. Scenarios 2, 3 and 4 can therefore be "ruled out". Preferably, the forensic autopsy should be supported by secondary findings such as an eyewitness report or a suicide note written by the person concerned, with the intention of drowning himself. These secondary findings are helpful and sometimes even necessary to make the diagnosis of drowning. However, this is not the current situation in the Netherlands; the criminal investigation and research into the cause of death is

closed without the involvement of a forensic autopsy in the majority of cases, even if a body is found in the water.
In most cases, the diagnosis of drowning is only established or rejected after an investigation is supplemented with an external examination by a forensic doctor. During an external examination the completely undressed body is examined for external abnormalities and research is done into the person's medical history. The forensic doctor can then choose to supplement the external examination with toxicological tests on urine or blood samples.[20] However, it is questionable how reliably options 2, 3 and 4 can be ruled out on the basis of these investigations.

Research questions and publication outline

This publication examines the value of the various aspects of the external examination of bodies found in water. In addition to a discussion of the epidemiology and the decomposition process, emphasis is placed on the development of pulmonary foam.
The definition of drowning established in Amsterdam in 2002 describes the respiratory involvement in the drowning process. As water enters the lungs, it causes pulmonary oedema. In approximately 70% of the cases there is pulmonary foam as a result of water mixing with surfactant.21 This is called internal foam. If this foam migrates outside of the body, it is known as external foam or external frothy fluid. In this publication, the forensic value of pulmonary foam is examined.

In ***chapter 2***, the epidemiological characteristics of victims of drowning in Amsterdam are described. This chapter deals with fatal drowning as well as non-fatal drowning and aims to provide insight into what the risk groups are, and where and when most people drown. It is useful to clarify these characteristics from a forensic point of view; additionally, preventive measures can be taken against drowning based on these characteristics.

Chapter 3 examines whether there is a relationship between the presence of external foam when bodies are found in the water and the post-mortem interval. The goal is therefore to establish the post-mortem interval more reliably.

Chapter 4 investigates whether or not (external) foam proves or supports the diagnosis of drowning using an animal experiment with post-mortem submersed piglet carcasses. The study specifically investigated whether (external) foam can also occur after post-mortem respiratory impairment from submersion liquid. This assesses whether the presence of pulmonary foam can rule out scenario 2, 3 and 4 as mentioned before.

Chapter 5 examines the Aquatic Decomposition Score (ADS) for bodies found in fresh water. The correlation between the ADS and the post-mortem period is described. The purpose of this study is to be able to more accurately determine the post-mortem period with less interpersonal variation. The adequate determination of the post-mortem period is of significance in the reconstruction of the event that led to death.

In addition to drowning, pulmonary oedema and/or (external) foam is also seen in heart failure, intoxication with opiates and neurological diseases.[22-24] ***Chapter 6*** shows that pulmonary oedema can also be observed after fatal *Taxus baccata* intoxications.

Chapter 7 shows that external foam can even be found after fatal *positional asphyxia*. The purpose of Chapter 6 and 7 is to show that (external) foam does not always indicate a drowning but it should be considered.

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