Karolinska Institutet, Department of Public Health Sciences
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The emergence and preservation of sick building syndrome

Research challenges of a modern age disease

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To my parents and Gudrun

”Vårt vetande mångfaldigas
- hur till slut rymma det?
Genom koncentration enligt principen
- Icke allt, men det hela - i delen.”

(”Our knowledge is multiplying
how make room for it?
By concentrating according to the principle
- Not all, but the whole - in the part.”)

Hans Larsson
Professor of Philosophy, Lund University:
Postscriptum, Albert Bonniers Förlag
Stockholm, 1944

CONTENTS

List of publications

The thesis is based on the following papers, which will be referred to in the text by their Roman numericals:

I. Thörn Å. Case report on a sick building: Analysis and interpretation in the context of its disease history. Scand J Soc Med 1994;22:228-34.

II. Thörn Å. Case study of a sick building: Could an integrated bio-psycho-social perspective prevent chronicity? Eur J Publ Hlth (Accepted for publication).

III. Thörn Å. The emergence and preservation of a chronically sick building. (Submitted).

IV. Thörn Å. Building-related health problems: Reflections on different symptom prevalence among pupils and teachers. Int J Circumpol Health 1998;57:249-55.

V. Thörn Å. The sick building syndrome: A diagnostic dilemma. Soc Sci Med 1998;47:1307-12.

VI. Thörn Å, Lewné M, Belin L. Allergic alveolitis in a school environment. Scand J Work Environ Health 1996;22:311-4.

Abstract

Since the 1970ies, the sick building syndrome (SBS) has become a common health problem. It is usually defined as a state of ill health consisting of subjective symptoms from mucous membranes and skin, as well as of general symptoms such as e.g. fatigue and headache. At the same time, demonstrable pathological alterations should be absent. Its occurrence is associated to a wide variety of factors related to the building, its indoor environment, work and work organisation, as well as to personal, individual characteristics of its inhabitants. The accumulated scientific knowledge on SBS is, however, vague and general, and the aim of this thesis is to contribute to the understanding of the development and maintenance of the syndrome.

Applying a multi-case study design, the thesis consists of six cases. Four focus on the buildings inclusive of their populations, while the remaining two put their centre on individuals. Information was retrieved from a wide range of historical documents. Data were also collected by questionnaire-based surveys as well as by semi-structured, open-ended interviews.

The case buildings had varying histories of proven or hypothesised water damage, ventilation defects and chemical emissions. Such conditions might have initiated the building-related health problems, which in turn seemed to generate protracted and complicated processes. These involved conflicting agendas between different parties within the buildings, and between the buildings and the surrounding society. This, together with structural conditions, such as e.g. economic and gender perspectives, seemed to influence the long-term outcome of SBS. Therefore, it was suggested that evolving sick building syndromes should be approached and analysed using integrated bio-psycho-social models. This seemed particularly important from an intervention aspect as there were indications that symptoms might persist in spite of rational corrective measures, taken from strictly bio-medical perspectives.

The thesis examined the concept of SBS and compared it with other building-related diagnoses. As a diagnostic concept, the construction of the SBS definition was shown to be inadequate. In spite of that, it was found to be used in legal contexts. This conveyed the ambiguous notion of a formal, individual diagnosis, which could have a normative and prescriptive force, which was one reason, why it was suggested that the term SBS should be abandoned.

Finally, methodological research aspects were examined. It was concluded that qualitative methods are well suited in the study of environmentally related, non-specific syndromes such as SBS.

Key words: quantitative methods, qualitative methods, sick building syndrome, multi-case study, building-related illness.

Glossary, concepts and abbreviations

Medical concepts

Aetiology[*] is the part of medical science dealing with the causes of disease.

Allergic alveolitis[*] is an inflammation of the lungs caused by an allergic reaction.

Asthma[*] is a disorder of respiration characterised by severe paroxysms of difficult breathing.

Chronic fatigue syndrome[**] various definitions are cited in the source. A duration of fatigue more than 6 months leading to substantial functional impairment is required, known physical and psychiatric causes should be excluded.

Diphteria[*] is an acute infectious disease, which is accompanied by a membranous exudation on a mucous surface, generally on the tonsils and back of the throat.

Humidifier fever[*] is a form of alveolitis caused by contamination of the water used to humidify, or moisten, the air in air-conditioning plants.

Idiopathic[*] is a term applied to diseases to indicate that their cause is unknown.

Legonnaire's disease[*] a form of pneumonia due to a bacterium known as Legionella pneumophila.

Multiple chemical sensitivity[***] is an acquired disorder characterised by recurrent symptoms, referable to multiple organ systems, occurring in response to demonstrable exposure to many chemically unrelated compounds at doses far below those established in the general population to cause harmful effects. No single widely accepted test of physiologic function can be shown to correlate with symptoms.

Phtisis[*] means wasting, and is the general term applied to that progressive enfeeblement and loss of weight that arise from tuberculous disease of all kinds.

Psychogenic[****] means originating in the mind, or referring to any physical symptom, disease process, or emotional state that is of psychological rather than physical origin.

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[*] From: Harvard CWH (ed). Black's Medical Dictionary. A & C Black Ltd, London, 1986.
[**] Wessely S. The epidemiology of chronic fatigue syndrome. Epidemiol Rev 1995;17:139-151.
[***] Cullen MR. The worker with multiple chemical hypersensitivities: An overview. Occup Med 1987;2:655-661.
[****] Andersson KN, Andersson LE (eds). Mosby's Pocket Dictionary of Nursing, Medicine and Professions Allied to Medicine. Mosby, London, 1995.

Sarcoidosis[*] is a chronic disease of unknown origin. It involves the skin, lymph nodes, eyes, salivary glands, lungs, heart and bones of the hands and feet.

Syndrome[*] is a term applied to a group of symptoms occurring together regularly and thus constituting a disease to which a common name is given.

Transient ischaemic attacks[*]*not* are episodes of transient disturbances of blood circulation of some part of the cerebral hemispheres lasting anything from a few minutes to several hours followed by complete recovery.

Tuberculosis[*] is the general name for the whole group of diseases associated with the presence of the Mycobacterium tuberculosis.

Epidemiological and methodological concepts[#]

Bias: Deviation of results of inferences from the truth, or processes leading to such deviation. Any trend in collection, analysis, interpretation, publication or review of data that can lead to conclusions that are systematically different from the truth.

Cross-sectional study: A study that examines the relationship between diseases (or other health-related characteristic) and other variables of interest as they exist in a defined population at one particular time.

Epidemiology : The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems.

Incidence: The number of instances of illness commencing, or of persons falling ill, during a given period in a specified population.

Prevalence: The total number of all individuals who have an attribute or disease at a particular time (or during a particular period) divided by the population at risk of having the attribute or disease at this point in time or midway through the period.

Reliability: The degree of stability exhibited when a measure is repeated under identical conditions. Refers to the degree to which the results obtained by a measurement procedure can be replicated.

Sampling: The process of selecting a number of subjects from all subjects in a particular group or ”universe”.

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[*] From: Harvard CWH (ed). Black’s Medical Dictionary. A & C Black Ltd, London, 1986.
[#] From: Last JM. A dictionary of epidemiology. Oxford University Press, 1995.

Validity, external: A study is externally valid or generalisable if it can produce unbiased inferences regarding a target population (beyond the subjects in the study).

Validity, internal: The index and comparison groups are selected and compared in such a manner that the observed differences between them on the dependent variables may, apart from sampling error, be attributed only to the hypothesised effect under investigation.

Abbreviations

BRI	Building-related Illness
HVAC	Heating, Ventilation and Air-Conditioning System
MCS	Multiple Chemical Sensitivity
MPI	Mass Psychogenic Illness
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
SBS	Sick Building Syndrome
VOC	Volatile Organic Compounds
TVOC	Total Volatile Organic Compounds
WHO	World Health Organisation

1 BACKGROUND

1.1 Introduction

My first encounter with non-specific, building-related health problems was in 1980, and had nothing to do with my professional role. I worked as a physician in a mining industry, and it was by rumours that I learned about some mysterious illness in newly constructed buildings in the community. Shortly afterwards, I participated in a university course on occupational lung diseases. There, an industrial hygienist told me about the sudden and widespread appearance of non-specific symptoms related to occupancy or work in new and elegant buildings in the city where he worked. He described the extensive resources and efforts he and his colleagues had dedicated to the investigation of such buildings, and for the, despite this, paucity of clues and findings as to causes. At the time, their work hypothesis was that the symptoms were due to imbalances of air ions.

Three years later, I worked as an occupational health physician at a health centre responsible for occupational environments such as schools, nurseries, offices, mechanical workshops and commerce. From then on, I repeatedly encountered the non-specific, building-related health problems, by then commonly referred to as ”**the Sick Building Syndrome**”. I entered in a sort of continuous feed-back interrelationship between my increasing experience from the many cases of sick building syndrome I became involved with, and what I learned from the results of the expanding research on the subject presented in journals, conferences and courses. This learning process resulted in the evolution of a growing discrepancy between my accumulating practical experience on the field, and the presented research results and expert advice. Gradually developed a gnawing feeling of something wrong, or maybe, insufficient in the way these problems were studied and handled. Finally, I was involved with an office where, during three years of billowing symptoms, two persons became seriously sick, one with a cerebral tumour and the other with transient cerebral ischaemic attacks due to arterial stenosis in one of the carotid arteries. Disturbances of memory, clouding of consciousness and vertigo were parts of their symptoms. Therefore, it was not surprising that these serious cases of disease, not at all related to the building, became incorporated in the occupants’ conception of possible, long-term, incapacitating and fearful outcomes of their own building-related symptoms: fatigue, vertigo, headache and difficulties in concentrating. And it seemed as, once incorporated in this conception, these non-building-related disease cases contributed to the maintenance of the building-related health problems. That experience was the final event which made me start a more systematic study of building cases, and which eventually led me to undertake this thesis.

1.2 History of indoor environment health problems

For centuries, contaminated air has been known, or suspected, to have negative consequences for health. Such effects were, not surprisingly, primarily observed in obviously dusty, occupational settings such as mines, quarries and workshops where stones and minerals were processed. Observations in such environments led Carl Linneaus in 1741, in his inauguration lecture when taking office as professor of medicine in Uppsala, referring to the grindstone production in middle Sweden, to ask: *" Why do almost all the men in Orsa die in pthisis before their 30th year of life?"* (1). Likewise, the obvious contamination of the indoor air due to improper diversion of smoke from open fires in the homes has long been known to cause serious discomfort and also morbidity in terms of chronic cough (2). This was the reason why many civilisations early in their history invented various techniques to solve the problem of how to heat buildings and at the same time keep them relatively free from pollution (3).

In the 18th and 19th centuries, a growing scientific knowledge (3,4) provided a more sophisticated basis for the need of an adequate ventilation, which resulted in hygienic recommendations regarding ventilation rates. However, not only polluted air was seen as a potential cause of discomfort or disease in indoor environments. Also draughty, damp, small and overcrowded houses were viewed as unhealthy in general, and as hallmarks of poverty (5,6,7). Such building-related factors were considered to promote the spread of infectious diseases like diphtheria and tuberculosis, to be detrimental to a good mental development, and also to give rise to problems with headache, vertigo, nausea, mucosal infections, stomach pain and rheumatic diseases (5,7). Consequently, an early public health goal in Sweden was the elimination of overcrowding, and the creation of dry, light and spacious dwellings (7,8,9) for all social layers of the population. The establishment of safe and healthy workplaces for the working population was another goal. With social policies and building- and workplace regulations, these goals became, to a large extent, accomplished after the Second World War (9,10,11). For several years thereafter, the question of buildings being responsible for causing or contributing to health problems was no longer a subject for deeper concern or debate.

This situation changed. Beginning in the 1970ies attention has increasingly focused on the emergence of health problems connected with non-industrial buildings, newly constructed or renovated during the period, such as banks, schools, day-care centres, offices and apartments. The upsurge of these problems is generally considered to be related to the Arab oil embargo in 1973 with the consequent need for more energy-efficient buildings in order to conserve fuel and heating costs. Further, it is

considered associated with the increasing use of synthetic building materials and with the growing proportion of workers within the office/service sectors (12-15). In the public health debate, as well as in the research which followed the emergence of these building-related health problems, two different terms became commonly used to describe them: "**Sick Building Syndrome**" to denominate a variety of diffuse symptoms, often seen as a new disease phenomenon, and "**Building-Related Illness**" to designate some better defined, well known diseases in situations where their appearance seemed to be associated with building occupancy. This thesis deals principally with the diffuse "Sick Building Syndrome". However, in order to illustrate some important contrasts between this term's vagueness and the better demarcation of the building-related illnesses, the latter concept will also be dealt with.

1.3 The Sick Building Syndrome

1.3.1 Definitions

The Sick Building Syndrome (abbreviated SBS) has been defined by the World Health Organisation (16,17) as a combination of general symptoms, as well as symptoms present in the mucosal membranes and skin (Table 1). Inherent in the definition is that the symptoms are related to residence or work in a certain building. Physical status, laboratory tests, x-rays and other medical examinations are as a rule normal (15,18-20).

Table 1. Core symptoms in Sick Building Syndrome (15,16)

Irritation of the eyes, nose and throat, cough
Experience of dry skin, rash, pruritus
Fatigue, headache, lack of concentration
High frequency of respiratory tract infections
Hoarseness, wheezing, shortness of breath
Nausea, dizziness
Enhanced or abnormal odour perception

The definition is flexible, and is best understood as a subject with variations. Different authors construct distinct definitions requiring somewhat different combinations of the core non-specific symptoms. There are also differences of opinion as to whether or not the definitions require the symptoms to be temporally related to presence in the building, that is, to appear while in the building, and to be ameliorated when away from it.

Table 2. Examples of variations of SBS definition in different studies

Reference	Type of source	Definitions	Time relation with presence in the building
(21)	Cross-sectional study	Non-specific symptoms more than twice the last year	Yes
(22)	Cross-sectional study	Non-specific symptoms a few times per week	Yes
(23)	Cross-sectional study	Two or more non-specific symptoms per week over the past 4 weeks	Yes
(24)	Thesis	General, mucosal and skin symptoms of the non-specific type outlined by WHO	No
(4)	Thesis	At least one mucous membrane symptom as well as one skin symptom every week, and at least one general symptom sometimes	No
(25)	Review	Non-specific symptoms with causes not recognisable	Yes
(12)	Review	Non-specific symptoms in people who work together in a common building	Yes
(14)	Review	An office building in which an ill-defined illness develops in one or more workers	Yes

In several of the sources given in Table 2, the definition of SBS has been formulated according to the respective paper's or thesis' research aims. These have been the epidemiological studies of potential associations between various building factors and SBS, and, in consequence, the resulting definitions have been constructed to serve those purposes. Such a case definition could literally be phrased as for instance by Sundell: *"Cases for the SBS study were defined as people reporting less than 1 h of daily work at a video display terminal and reporting the presence of symptoms from all 3 symptom groups: at least one mucous membrane as well as one skin symptom "Yes, often (every week), and at least one general symptom "Yes, sometimes". Originally the same criterion "Yes, Often" was used also for general symptoms, but the number of cases became to small"* (4).

In the review articles, on the other hand, the definitions seem to be constructed with the intent to guide the practical handling regarding investigation and remediation of case buildings as well as to aid in the diagnosis of SBS in human subjects. For such purposes, the research definitions are insufficient. There is a need for additional qualifications, and in most instances, this need is resolved by adding two requirements to the ones appearing in the table. The first is that only when the symptoms occur with increased frequency in determined buildings, should SBS be considered present (12,14,15,25,26). Quantification of what should be considered an increased frequency is rarely given, but it seems as if it is interpreted as a prevalence in excess of 15 % (27) or of 20 % (25,28). The

second additional requirement is that other, alternative states of ill health explaining the non-specific symptoms should be excluded (13,26,29,30). The definition used by Redlich et al can be quoted as an example of a literal phrasing of such a diagnostic definition: *"The diagnosis of SBS is based on the patient's clinical presentation, the presence of similar symptoms in co-workers, improvement in symptoms away from the building, the lack of pathophysiological abnormalities, and the absence of any other likely diagnosis"* (15).

1.3.2 Criticism of the SBS definition

In summary, there is a wide variety of SBS definitions, all of them rather vague, and during the last few years, criticism has been addressed at the use of this term. The criticism is based on the absence of consistent case definitions, the lack of biological markers, and the failure to identify consistent associations and building (environmental) contaminants (14,31). Several authors have pointed out these shortcomings and their consequences. In research, they lead to serious problems of validity in the epidemiological analysis (14,32-34) as well as to the impossibility of comparisons between investigations (34). The term SBS suggests that the symptoms actually are caused by factors in the building, and mislead laymen as well as scientists to believe that there is a common aetiology (35). The vague syndrome definition, with its literal reference to a potential cause, makes it difficult to decide whether the syndrome reflects a health hazard, or an altered causal attribution/interpretation of normally present, base-line non-specific symptoms (31,32). In clinical praxis, Bardana (14) suggests that the key issue, which has given some credibility to the term SBS, has been the time-relatedness of the symptoms to the physical presence in the building. When, as has happened in several instances (4,24,36), temporality is no longer maintained in the definition, the term SBS is believed to contribute to the evolution of other vague diagnoses in affected individuals, e.g. "multiple chemical sensitivity" (MCS), "chronic fatigue syndrome" (14). Baker (37) argues in a somewhat similar way that by the use of the term "sick building syndrome", one tends to medicalise an essentially environmental problem, thereby raising a spectre of concerns for unknown deleterious health effects. Thus, there are several reasons why authors have proposed a change of terminology. Baker (37) recommends that buildings with building-related health problems should be called just "problem buildings." Stenberg (36) proposes the adoption of a new syndrome denomination, Indoor Air Syndrome (IAS), while Bardana (14) suggests the abandonment of the concept of syndrome and proposes the term "idiopathic building intolerance". Järvholm (35) and Spurgeon et al., (31), on the other hand, propose the adoption of a more descriptive approach, in which e.g. a

sore throat is called a sore throat. Menzies and Bourbeau (20), finally, suggest the replacement of the concept of Sick Building Syndrome" with the term "non-specific building-related illness".

1.4 Distribution of non-specific symptoms in general

Non-specific symptoms of the SBS type commonly occur in the general population, making it important to try and estimate the size of that "base-line" (32) occurrence. This prevalence is variable but seems to be between 20 and 50 % (31) in different populations. One large survey in the USA, reported the occurrence of 40-55 % with headache, 33-46 % with fatigue and 15 % with sore throat at the time of the survey (38). Lipscombe et al (39) found the one-year prevalence rates to be, respectively, for skin irritation 21.9 % for women and 15.5 % for men, eye irritation 45.9 % for women and 38.7 % for men, sleep disturbance 42.1 % for women and 36.5 % for men and fatigue 49.2 % for women and 43.4 % for men when the information was collected by mailed, self-administered questionnaires. When the information was collected by in-person interviews, the same prevalence rates were substantially lower: skin irritation 11.2 % for women, 9.0 % for men, eye irritation 25.3 % for women and 13.0 % for men, sleep disturbance 17.2 % for women and 9.1 % for men, fatigue 18.9 % women, 9.1 % men. In a review article, Stewart (40) estimated that the average US adult experiences four symptoms, mostly vague ones, on every fourth day. Kroenke and Price (41) found the life-time prevalence rates for fatigue and dizziness to be 23.6 % and 23.2 %, respectively, in a large population sample. Verbrugge and Ascione (42) quote findings of prevalence rates for headache of 39-56 % and of cough from 21-34 %, and the Lundby (43) prospective epidemiological survey in Sweden has shown a high lifetime risk of tiredness. General fatigue and headache were prevalent in rates between 12 and 58 % in two population studies in Sweden, highest among the women, and decreasing with age in both sexes (44). In Britain, the prevalence rate of fatigue was 38 % in a general population (45), and in the USA, the prevalence of wheezing exceeded 30 % (46). Also populations in non-problem office buildings report high prevalence rates. For instance, a New Zealand study with the aim of establishing the background prevalence of symptoms in office workers in non air-conditioned buildings found sore throat in 25 %, dry skin in 26 %, headache in 42 % and problems of concentration in 14 % of the building occupants (47). An American study found similar rates in four non-problem offices (48).

1.5 Distribution of SBS

Due to the arbitrary definition of the syndrome, it is not possible to make other than very crude estimates of the general prevalence of SBS. A committee connected with the WHO (49) calculated that about 30 % of the buildings in Western Europe and North America could have SBS problems. A survey of 1740 municipal buildings in Malmö found that 25% of them have building-related health problems, and 40% of all schools built in Sweden after 1976 have been reported to have health problems related to the indoor air quality (50). An inventory of residential buildings in Sweden (51) estimated that between 600,000 and 900,000 persons are exposed in their residences to an indoor air that could adversely affect their health and well-being. Apter et al (52) argue in a review article that 50% of the US population is affected negatively by indoor air. It is believed that 0.5 million days of work are lost yearly in the USA because health problems in offices (53). Such estimates are substantiated by several epidemiological studies of office buildings from the 1980's and beyond which have shown a high prevalence of building-related, non-specific symptoms (Table III).

Table III. Epidemiological studies of symptom prevalence.

Reference	Number of buildings in study	N	Prevalence, % of most common symptom	Type of symptom
(21)	42	4373	57	General
(54)	61	7043	23.5	Mucosal
(55)	?	4943	16*, 28**	Mucosal
(56)	14	3757	36	General
(57)	1	1370	49	Mucosal

* Men, ** Women

Like the studies represented in Table III, an American investigation of a large office population found a high overall prevalence of SBS-like symptoms, 45 % (28). However, in this study an attempt was made to separate the presence of non-specific symptoms which reasonably could be attributed to non-building circumstances. Symptoms attributed to allergy, cold or flu as well as symptoms that were not more severe at work were considered not to be building-related. When these symptoms were subtracted, the remaining estimated SBS prevalence was substantially lower than at first, only 5 %.

1.6 Causes of the sick building syndrome: An overview

Since the 1970ies, research units and authorities, such as e.g. NIOSH, have done a large number of studies of buildings including their populations (12,14,15). Few of these have been performed using clinical outcomes. Some such studies have demonstrated alterations of tear film stability to be significantly more common in office-workers from SBS buildings than in workers from other offices, or in the general population (58-60). Another study demonstrated a proneness to nasal hyperreactivity as determined by rhinometry in subjects living in a residential area with building-related health problems (61).

Besides some experimental studies (62-65), the vast majority of the SBS research consists of epidemiological, cross-sectional studies of single, or groups of buildings selected in different ways. Some of the studies have selected buildings with randomised sampling procedures in order obtain representativity for the offices and office populations in their respective regions (23,36). In others, buildings have been chosen specifically on the basis of their not having had any known building-related health problems (21,48,54). For comparative studies, still others have selected buildings with different ventilation systems (66,67). Some researchers have selected building populations without known health problems in order to study prevalence rates before and after moving to new offices (68-70).

Together, these studies have demonstrated a large variety of associations between symptoms and building-related, as well as not building-related factors. Examples of such factors are: mechanical ventilation (67), especially with air conditioning (71), volatile organic compounds (VOC) (72), lighting (73), formaldehyde (74), dust, wall-to-wall carpets, textiles (75-77), noise and reverberation time (75), low-frequency noise (78), indoor temperature (79), beta-1,3-glucan (80), dampness and mould (81-83), work involving photocopying, self-copying paper or work at computer terminals (22,55), number of clothing layers on the body (84), office landscape with work places delimited by partitions (85), density of people in work locations (54), subordinate position in the work hierarchy (21), sensitivity to chemicals (86), female gender, tobacco smoking, atopic disease history and psychosocial discontent (22,54,55,87,88).

1.6.1 Four repeatedly demonstrated factors

Some of these factors have just been demonstrated sporadically, though four have generated particular interest. First, there are the ventilation systems, especially those with air-conditioning (15,52,71,89).

Second, there is dampness, damp buildings, with or without fungal colonisation, which classically have been held responsible for allergies, infections and SBS-like symptoms (81,90,91).

Third, there are the volatile organic compounds, VOC, which have become the metaphors for potentially deleterious low-level chemical emissions from modern building material (72,84). When practically dealing with a building with non-specific health problems, these three factors commonly constitute the principal lines of recommended remedial actions: secure an optimal ventilation, eliminate and avoid water damage, avoid material that may act as microbial substrates and select material as little likely as possible to release pollutants (20,92).

Fourth, the multitude of demonstrated associations has led to an extensive agreement that SBS is a multifactorial condition, whose symptoms have a global background originating in individual constitutional and habitual, as well as psychosocial and physical environmental risk factors (36,93). This is the conclusion of several review articles (15,19,20,33,52,92), which, however, have different opinions as to which of the distinct factors in the multifactorial spectre are the most important. According to Redlich et al. (15), the two dominant features are air contaminants, and the ventilation system which should remove them and supply the occupants with fresh air. Also Menzies and Bourbeau (20) seem to minimise the role of psychosocial factors, in spite of their review being based on seven major studies, which all found an association between psychosocial factors and non-specific symptoms (94). On the other hand, there are also review articles which argue for a strong role for occupational stress in the causa-tion of non-specific building-related health problems (32,33), and Ford (95) cites SBS as an example of a somatisation syndrome.

1.6.2 Ventilation

Because of their central function in diluting and removing contaminants, much attention has been focused on the buildings' ventilation systems. Epidemiological studies have demonstrated that non-specific symptoms are more common in buildings with mechanical ventilation than in such with natural ventilation, and most common in such with air-conditioning (21,54,66,67,96,97). Sundell and co-workers found (98) that low outdoor airflow rates (<13.6 l/ s,p) were associated with SBS. A Canadian study (69,70) demonstrated a significant decrease in the prevalence of non-specific symptoms after a work-force moved from older offices with sealed windows, mechanical ventilation, air-conditioning and humidification. The new office, to which they moved, also had sealed windows but was, however, equipped with a better designed, operated and maintained system of mechanical ventilation, air-conditioning and humidification. Finally, several major

reviews (15,19,20,71,89) conclude that there is a consistent association between SBS prevalence and mechanical ventilation with air-conditioning.

However, there also exist several naturally ventilated buildings with markedly more complaints of non-specific symptoms than in some mechanically ventilated ones (99). There is no direct relationship between air change rates and SBS, and it is not considered likely that increases in fresh air supply will eliminate symptoms in problem buildings (100). Thus, the role of ventilation for the appearance of SBS seems to be complicated, and has not been able to be settled by a number of experimental studies. In a hospital ward, variations of outdoor air flow rates by 30% upwards and downwards did not result in changes in the prevalence of symptoms among the personnel (62). In two offices, variations in the supply of outdoor air, blinded to the personnel, were not associated with changes in symptom frequency (63). In still another office, there was a small increase in prevalence associated with a 75 % decrease in the ventilation rates (101). In Canada, the ventilation systems of two office buildings were manipulated in a randomised double-blind, multiple-crossover manner to deliver different rates of outdoor air (64). The study demonstrated an increased report of mucosal symptoms related to increased concentrations of NO_2 and TVOC in the indoor air, and of systemic symptoms related to increased concentrations of dust.

1.6.3 Water/moisture/humidity

Historically, damp buildings have been associated with the occurrence of disease (5,7). Commonly the association has been with respiratory symptoms, but also correlation with vomiting, aches, headache and diarrhoea has been noted (91,102). A dose-response pattern between such symptoms and the severity of dampness and mould has been demonstrated (90). Studies have also shown that SBS symptoms were significantly more frequent among workers in day-care centres that had problems with dampness and mould (81,103). Also, it has been demonstrated that building factors, which facilitate water leakage or transport, such as horizontal roofs and foundations of the ”concrete slab on the ground” type, are risk factors for SBS (104-106). Similarly, there is a substantial risk for the accumulation of moisture and debris in ventilation ductworks, and, because of this, the colonisation by micro-organisms (83,107,108). Compatible with this, a recent US study (109) of 48 schools with non-specific health problems demonstrated that fungal Penicillium and Stachybotrys species were strongly associated with SBS. The study findings further suggested that the microbial growth was to do with poorly maintained HVAC systems and

active water leaks.

On the other hand, the role of dry air seems to be more ambiguous. The perception of it was in one study strongly correlated with the prevalence of SBS symptoms, while, contrariwise, there was no association between the measured relative humidity and the symptom prevalence (110). In other studies, however, humidification of the indoor air was demonstrated to decrease symptoms such as dryness of skin, throat and nose, nasal obstruction as well as the perception of air dryness (111,112).

1.6.4 Volatile Organic Compounds (VOC)

These chemical contaminants are frequently present in the indoor environment of buildings. They arise from a great number of sources: e.g. building material, cleaning products, paints, adhesives, glues and furniture, office machines such as duplicators, photocopiers and laser printers, and office materials such as paper and typewriter correction fluid (14,113,114). Chemically, among the large variety of VOCs that can be identified in the indoor air, aromatic and aliphatic compounds are the most common (113,115). Epidemiological studies have demonstrated associations between exposure to low-level VOC and the presence of non-specific symptoms of the SBS-type (72,84). Other epidemiological studies have failed to show such associations (75) while still others have demonstrated negative associations (4,27). No study has shown the concentrations of VOCs to be convincingly higher in sick office buildings than in healthier ones (100). Studies on humans in exposure chambers have demonstrated the effects of VOCs leading to decreased odour thresholds, dry mucous membranes and reduced cognitive performance as measured by digit span recall (116), and dose-response relations have been discussed (65). The relevance of such experiments has been questioned. The most serious criticism is that in the chambers, the concentrations of VOCs have been higher than those found in non-industrial buildings (117). It can be concluded that the existence of causal links between specific VOCs, groups of VOCs or the total concentration of all VOCs (TVOC) and SBS symptoms has yet to be established (14,117).

1.6.5 Psychosocial factors

Psychological effects of indoor air pollution were discussed before the expression SBS was coined in 1983. For instance, in 1981 Colligan (118)

meant that the indoor air can affect an individual psychologically in two ways. First, it might do so by direct and specific neuro-behavioural effects of an individual pollutant. Secondly, Colligan argued, it can affect psychological functioning in a more diffuse way involving the overall impact of the environment on the autonomic nervous system. In this respect, indoor air constitutes one of many possible sources of stress producing a state of general discomfort. The perception of the indoor air becomes integrated in a complicated process by which the individual interprets his internal states with the aims to understand their significance in terms of health, and with the purpose of finding ways of coping with the situation. Other researchers (32,119,120) have more recently discussed similar mechanisms as possibly involved in the causation of non-specific building-related health problems, and have also pointed out similarities between these and so-called MPI (mass psychogenic illness).

Today, there are several surveys that have identified psychosocial factors as being associated with the prevalence of non-specific building-related health problems. For instance, work stress was shown to explain twice as much of the symptom variance as the environmental factors that could be quantified (84). Skov et al. (22), and Norbäck and co-workers (88) found positive associations between the psychosocial climate at the workplace and the symptom prevalence rates. In one study of three offices with a total of 3948 workers, heavy workload, conflicting demands and job dissatisfaction were associated with headache, dizziness, fatigue, difficulty in concentrating, eye irritation, bodily aches and pains, chills and nasal and chest symptoms (86). Later, researchers (68) found psychological symptoms, together with female sex, to be the most important independent predictors of perceived building-related health problems. Similar results were obtained in Asian studies, where it was demonstrated (121) that stress was a significant and independent determinant of the building-related health complaints. A Swedish study (93) demonstrated that psychosocial factors originating from different aspects of the workplace were significant determinants for the non-specific building-related health problems. Other research results likewise indicate that psychosocial factors have an important role in the causation of building-related health complaints, but also underline that they cannot be justifiably attributed to such factors alone (122). Rather, it has been proposed that each building problem arises out of dynamic interactions among a multitude of psychosocial, environmental, toxicological and organisational relationships (37).

1.7 Patho-physiological mechanisms

It has been suggested (123-125) that the SBS symptoms are caused by a disturbance in the sensory perception which, through its distinct components, registers low exposures in the environment. According to this theory, the sensory modalities might merge different stimuli into a ”unity perception”, for example ”eye irritation”. Because of this fusion of perceptions the possibilities of distinguishing cause/effect relationships between a certain exposure (stimuli) and a registered perception (for instance ”eye irritation) are hampered. Another recently proposed model involves so-called ”neurogenic switching”, where a sensory impulse at one site (caused, for example, by chemical irritation in the respiratory mucosa) is redirected by means of liberated neuropeptides to some distant organ, for instance, to the central nervous system. There vasodilatation and oedema are suspected to occur (126), which could lead to such SBS symptoms as headache, fatigue and deteriorated capacity for concentration.

1.8 Building-related Illness

1.8.1 Definitions

Building-Related Illness (abbreviated BRI, synonyms sometimes used are Building-Associated Illness (18) and Specific Building-Related Illness (20)) is defined as diseases related to buildings, and which have at least a partially known aetiology with relatively well defined pathogenic mechanisms and pathophysiological changes (19). These disorders often have clinical manifestations that can be recorded objectively. Table 4 provides examples of such BRI.

Table 4. Examples of Building-Related Illnesss and corresponding etiologies

BRI	Etiology (exposure)
Asthma	Mould, mites, dander
Allergic alveolitis	Mould, other protein antigens
Humidifier fever	Endotoxins
Legionnaire’s disease	Bacteria (Legionella pneumophilus)
Lung cancer	Radon/ Radon daughters

The definitions of the disease states included in BRI are more precise and delimitable than those of SBS. For example, the diagnostic criteria of

asthma generally include both a well-defined case history and objective criteria, like reversible bronchial obstruction (127,128). The criteria for allergic alveolitis, similarly, include both the fulfilment of certain case history requirements and a number of measurable examination findings such as the presence of precipitating antibodies, radiologically verifiable lung changes and restrictive respiratory impairment (129-132).

The fundamental distinction, then, between SBS on the one hand and BRI on the other, is that the former is a clinical description of combinations of subjective symptoms in the setting of normal physical and laboratory findings, whereas the latter in addition has physical changes and abnormal laboratory findings (18).

1.8.2 Distribution of BRI: Asthma and allergic alveolitis

The distribution of the specific fractions of asthma and allergic alveolitis prevalence rates related to non-industrial indoor environments is not known. However, *asthma* has increased in occurrence in recent decades (127,128). The highest distribution, and the biggest increases have been found in northern Sweden (133,134). The prevalence of asthma among adults in the northernmost county of Sweden, Norrbotten, was 5 % in 1986, while it was 6 % in 1992 (127). Both the increase and the geographic north-south gradient are considered to be at least partially due to changes in indoor environment.

Allergic alveolitis usually occurs in agricultural, animal husbandry and forest industry environments. A prevalence between 5 % and 10 % has been found among trimming workers in the Swedish sawmill industry (135). The incidence among agricultural workers in Sweden has been calculated at 2 to 3 cases/10,000 persons per year (136), while in Wales it has been calculated at 19.3 cases/10,000 persons per year (137). The disease has normally not been connected with non-industrial or non-agrarian indoor environments. Isolated reports, however, in recent years have described its occurrence in offices (138,139), cafeterias (140) and in homes (141). In such indoor environments, it seems as if allergic alveolitis most often occurs in buildings with SBS problems (18,29,52,142).

1.8.3 Causes of BRI: Asthma and allergic alveolitis

Asthma can be caused and maintained by very different factors in the indoor environment, for example dust, mites, cigarette smoke, NO_2 and SO_2

from gas ranges and heating elements, VOC from detergents, furniture and carpets (143). The higher prevalence in northern Sweden is thought to be due to the fact that the houses there are better insulated, tighter than in the south (50,127) and therefore with a conceivably higher degree of pollutants indoors. The pathogenic mechanisms behind the development of the disease can be both immunological and irritative. The latter mechanism is most common among adults.

Allergic alveolitis has an immunological pathogenesis and the disease is generally triggered by antigens in the form of organic dust originating from bird proteins, bacteria or mould fungi (129,143,144). When the antigen originates from sources indoors in buildings (for example, mould growth in dwellings) the disease is included under the term BRI.

1.9 Methodological aspects

In spite of a substantial volume of research, the knowledge regarding the causes of SBS remains vague, and like the syndrome itself, non-specific. As has been reviewed previously, it seems to be related, albeit ambiguously and sometimes contradictorily, to ventilation, and to humidity and its possible consequences: microbial growth and chemical emissions. There also is a growing body of evidence supporting a causative role for psychosocial factors. However, the sum of this knowledge is so general that it has been claimed that *"the science to support prevention, correction, and the setting of standards is woefully undeveloped and unsupported"* (145). This non-specific, or undeveloped, nature of the accumulated SBS knowledge might be due to methodological difficulties related to its study.

Generally, a number of different study designs are used, and in a review article, Apter et al (52) discuss those most frequently utilised: semi-experimental, epidemiological and anecdotal studies. The semi-experimental studies principally consist of two forms. First, there are intervention studies in which ventilation rates have been changed after which the symptom response of the building occupants has been registered. Apter and co-workers find that the results of such studies are inconclusive, and, further, that the study method is not likely to be successful if SBS has more than one cause. Second, there are laboratory studies with controlled human exposures in chambers. As previously reviewed, the relevance to SBS of such exposure studies has been difficult to evaluate (4,117).

1.9.1 Problems with hypothesis testing

Epidemiological study methods are the major approaches in the SBS research. Used for such purposes, their dominant methodological problems are connected with the definition and characterisation of exposure, and with limitations of sampling procedures of buildings, hampering the interpretation and generalisation of results (52). The absence of a well defined potential disease outcome, that is, a case definition of SBS made on the basis of objective criteria (14,28,32,71), contributes equally to these problems. All in all, the methodological difficulties (which essentially lie in the inability to adequately characterise the exposure, consisting of a large number of hypothesised causative agents, as well as the outcome, consisting of a large and variable number of subjective symptoms) make it difficult to test different research hypotheses (20). SBS shares these difficulties with other non-specific environmental syndromes, such as e.g. MCS, which, as defined, does not provide testable hypotheses (146).

On the other hand, in this context, SBS could usefully be contrasted with BRI. From an epidemiological research standpoint, the conditions belonging to this latter category have a more favourable position. There are established, objective diagnostic criteria for the disease outcomes, as well as better defined, known or reasonably well suspected causative exposures which, as a rule, can be at least partially characterised (Table 4), thereby facilitating the formulation of testable hypotheses. In epidemiological studies, asthma, for instance, can be defined by a combination of elements from the subject's disease history as well as from objective criteria regarding bronchial function (127,128). Lung cancer is another example of an objectively well categorised disease, which sometimes is related to indoor exposure to radon in dwellings, and where the degree of exposure often can be estimated with some precision (147).

1.9.2 Validity problems

Besides problems with hypothesis testing in the study of SBS, there are many forms of bias which cannot be readily controlled, weakening study validity. Examples of these are selection bias (healthy worker effect, non responders, problem buildings among the populations of buildings), publication bias, response bias owing to awareness of the problem and problem hypothesis, recall bias and mis-classification. With a subjective case definition, the available epidemiological study design is the cross-sectional one with its inherent errors. The studies have to be based on cases constructed out of self-report questionnaires (33) which cannot be validated against objective measures. Such questioning procedures are more likely to

lead to response bias than others (148), resulting in an upwardly biased symptom reporting (28,71). However, most problematic with the absence of an objectively validated case definition is that it opens up for a sort of unlimited mis-classification. Ooi et al (23) discuss this somewhat in their study. They demonstrate that the prevalence of SBS varies with the specificity of criteria used to define a case, and to which extent other causes have been excluded. This problem was not resolved by the use of empirical definitions based on proportions, e.g., in excess of 20 % - 30 % of workers in the building being affected.

1.9.3 Critical issues

In a review article (12), which in its abstract provocatively states *"SBS might properly be paraphrased as What is it? - if it is"*, Chang et al. comprehensively discuss the methodological difficulties in the study of SBS. They mean that, to be useful, the epidemiology of SBS has to become more stringent, and therefore has to define a number of critical issues *1) "What are the specific symptoms that are claimed to be work related?", 2) "What is the temporal relationship of these symptoms and presence in the workplace?", 3) "Are there objective ways to monitor these symptoms?", 4) "If buildings are the cause, what specific aspect of the building?"* and *5) "Does removal of the inciting agent, once determined, result in the eradication of symptoms?"*

With these propositions, for SBS epidemiology these authors suggest what in essence almost is a sort of Koch's postulates* :*"We suggest that it is not sufficient to attribute SBS simply to defects in ventilation, entrainment of outside contaminants, humidity, contaminants from fabrics, or noise. We must be able to objectively test the effects of exposure to a specific agent at concentrations comparable to that which is seen in the building concerned, and if a correlation is seen, show that removal of that substance is associated with resolution of symptoms."*(12).

Similar suggestions have been advanced by Molhave (149), who also conclude that their fulfilment would be very cumbersome and costly.

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* Koch's postulates are applicable in the field of infectious diseases and rule that four conditions must be satisfied to establish the causative organism of a specific disease: 1) The organism must be present in every case of the disease, 2) the organism must be isolated and grown in pure culture, 3) the pure culture must produce the disease when inoculated into a susceptible animal, 4) the organism must be recovered from the infected animal, and grown again in pure culture.

1.9.4 Corroboration of models

With the aim of explaining the aetiology and genesis of SBS, there exist bio-medical models which stand by themselves (20,123,126) or in the combination with psycho-social ones (33,53). None of the models, nor any form of combinations of them have been corroborated with sufficiently valid empirical data to permit the generalisation of either the model or its implications. This failure depends on the questions of validity which have just been reviewed. It seems doubtful whether a sufficient degree of validity could be accomplished with epidemiological research methods without the adoption of criteria identical or similar to those proposed by Chang et al. (12). Unfortunately, these criteria, stringent though they may be, seem to be difficult to realise presently in a practical situation - the symptoms exist but remain subjective and without the possibility of objective validation, while the exposure remains apparently unknown and difficult/impossible to define. Again, the comparison with BRI could be useful: to be realisable, criteria like the ones of Chang et al. require case and exposure definitions as assessable as the ones of the BRI group.

1.9.5 Case (anecdotal) studies of SBS

In their review (52), Apter et al. refer to a research approach, which they call anecdotal investigations. These are studies of cases, or series of cases of buildings with health problems, and can be of somewhat different designs (85,150,151). One example of an anecdotal design is a questionnaire survey with limited environmental measurements in a big office where the occupants all had made health complaints since the building was inaugurated six years preceding the study (57). An example of a different design is a medical evaluation of work-forces from two buildings with serious building-related health problems. Symptomatic and non-symptomatic cases were compared as regards to symptoms and clinical examination findings, including neurological functioning (152).

As a rule, these anecdotal investigations have been designed and performed as case studies within relatively strict epidemiological perspectives. This means that their foci have been on exposure and disease outcome, while the context, within which exposures and outcomes develop, has been disregarded. Case studies conceived within such perspectives suffer from the same problems of validity as the more regular epidemiological studies of SBS. The problems are probably even greater owing to the buildings not being selected from one or another sampling procedure, but rather because of on-going problems.

1.10 Alternative case study design for SBS investigations

With SBS as an obvious example, the study of all environmentally related non-specific symptoms (31,153) suffers from the methodological difficulties just reviewed. This is to do with the apparently unknown associations between symptoms and exposure and the resulting problems in defining either disease or cause (31). For such reasons, a need for the application of other research methods than traditional epidemiological ones has been pointed out (31,33,153). Several authors have argued for the use of qualitative methods in medical research (154-156) as a complement to quantitative ones. In the study of environmentally related non-specific symptoms like e.g. SBS, such a complementary use of qualitative methods might be especially appropriate. Like quantitative methods, they can address causal aspects (154), but differently from the former applying particularly to situations where relevant variables are not apparent and contexts ill defined, uncontrolled or situational (154,157). Case studies designed within a holistic, qualitative perspective are frequently used in the social sciences (158,159). They differ from the cited "anecdotal" SBS case studies, in that their pretensions are inductive - their objectives are not to test hypotheses that have been deduced from one or another theory. The aims are rather to find out "how" or "why" events occur in situations over which the investigator has little or no control (158), and by that achieve a holistic, intensive description and interpretation of some phenomenon (159). It is claimed that this type of approach can prove particularly disclosing, when the boundaries between the investigated phenomenon and the context are ill defined (158). If so, that quality would make them particularly suitable for the study of SBS, which, according to all variants of definitions is a *phenomenon*; e.g. "a collection of symptoms occurring with increased frequency" (160); *within a context*; "in some proportions of buildings" (160). With such definitions, clear boundaries between symptoms and context are unlikely. It is therefore possible that a case study design, focusing on contexts and relying on multiple sources of information, could facilitate the understanding of how the interaction of many inter-related factors might explain the emergence and preservation of sick buildings (157-158).

1.11 Methodological considerations on the alternative

1.11.1 The author's preconceptions

Briefly, I want to comment on my previously mentioned gnawing feeling of discontent with the way sick building syndromes were studied and handled. I do this because my gradual understanding of the reasons for that feeling could be an important part of those of my preconceptions, which might affect the results of this thesis. What, then were the reasons?

Fundamentally, they were to do with a growing dissatisfaction with the almost complete absence of the buildings' complex contexts in most of the SBS research that I encountered. This resulted in a diminished trust in the reductionist perspective of most of the work in this field, which, expressed in the words of Merriam (159), *"all too often fragment (life) into 'manageable' bits, which conceal from us the context-embeddedness of social phenomena, their dynamical coherence, their reflexive effects".*

1.11.2 Case study design

In case study research, distinctions are made between single-case designs and multiple-case designs (158). The rationale for a single-case design is often that the case represents a critical issue or an extreme or unique incident. Single-case designs might be "intrinsic" (161) and are generally undertaken with the aim of acquiring a better understanding of a *particular* case. In intrinsic studies, the cases are not chosen by the researcher. They are for some reason or other (e.g. uniqueness) pre-specified and of prominent interest before the formal studies of them begin (161). However, single-case designs might also be "instrumental". In such a design, the case is chosen by the researcher because it is expected to facilitate a deeper insight into an issue or theory. Multiple-case designs (158), synonymous with the collective case study (161), deal with more than one case. In this design, the cases regularly are chosen. The selection principles are similar to the ones practised in the instrumental single-case designs: particular cases thought to represent one or another critical issue are selected in order to enhance the understanding of complex phenomena.

1.11.3 Reliability and validity issues

Even though medicine often has relied on qualitative data from clinical case studies in order to illustrate important and interesting phenomena (162), its

research tradition is dominated by quantitative methods and study designs, such as for instance the randomised controlled clinical trial. Within this tradition, the concepts of reliability and validity have relatively determined, well-established meanings as e.g. exemplified in the introductory glossary of this thesis. Corresponding to these meanings, there exist procedures designed to estimate to which extent a study is reliable and valid. The case study, on the other hand, relies to a large extent, or entirely, on qualitative research methodology. Within that methodological sphere, it is equally necessary to assess the reliability and validity of performed studies. The objective of such assessments is not different from that of quantitative investigations, i.e. the ascertainment if a study's interpretation is valid relative to its intent (163). However, the terms *validity* and *reliability* are generally not considered appropriate in qualitative research. In stead, the concept of *trustworthiness* is often used (163). *Trustworthiness*, in turn, is defined by the terms *credibility*, *transferability*, *dependability* and *confirmability*. Translating these concepts into approximate, corresponding quantitative terms results in the following: *Credibility* corresponds to *internal validity*; *dependability* to *reliability*; *confirmability* to *objectivity*; and *transferability* to *external validity*, that is to *generalisability* (164).

To then assess the trustworthiness of a study, the reader has to be able to evaluate the researcher's position and presence in the context of the study, as well as his preconceptions (159,165,166). Further, the reader also should be able to make such a close examination of the work's different components, e.g. its conceptualisation, the way data were collected, analysed and interpreted, that it would be possible to analyse the distinct sources of bias which might invalidate interpretations and conclusions (159). In order to enable that kind of examination, there is a need for a clear, "transparent" (167) presentation of all parts of the investigation so the reader can follow an "audit trail" (159). It should be evident how and why selections, e.g. of cases, informants, observed persons (163,167,168) were done. It should be clear to which extent different and independent sources of information have been used (so called "triangulation"), and how these mutually concur (159,167,169). The reader should be able to evaluate to what extent the researcher in his interpretation of data has pursued alternative interpretations or rival explanations (158,159,166,170). There are several other elements, which the presentation should make visible, and the elements might vary somewhat between different studies. Ultimately, however, the validity of a qualitative study is often equated with what has been called, respectively, communicative and pragmatic validity (165). The former type of validity resides in the credibility and utility ascribed to the study by its readers, while the latter type resides in the practical implications deriving from the findings and conclusions.

2 OBJECTIVES OF THE THESIS

2.1 Main objective

In general terms, the main objective of this thesis is to contribute to the understanding of the development and maintenance of building-related, non-specific health problems of the sort which are often designated by the term **SICK BUILDING SYNDROME**. This objective is addressed in two ways. First, by the study of six individual parts (Papers I-VI), and then by the unification of these parts to a whole, which subsequently is analysed; that is, this thesis.

2.2 Sub-objectives

The parts (Papers I-VI) as well as the whole (Thesis) address specific sub-objectives:

- Investigate whether interactions of social, psychological, physical, communicative and organisational processes inside as well as outside of the building might influence the evolution, interpretation and maintenance of symptoms (Papers I, II, III, and Thesis).
- If encountered, examine and discuss why and how such interactions might play a role in making a building ”chronically” sick” (Papers I, II, III, IV, V, and Thesis).
- Provide models for the practical handling of buildings with building-related health problems (Papers II, III, IV, and Thesis).
- Investigate and discuss the complexity of the conceptually vague term Sick Building Syndrome, and whether this complexity might influence the appearance and evolution of symptoms (Paper V, VI, and Thesis).
- Focus a discussion on complementary models and study approaches to the study of sick building syndrome. Address methodological problems inherent in the study of subjective, non-specific symptoms which cannot be validated objectively (Papers I, II, III, and Thesis).

3 MATERIAL AND METHODS

3.1 Cases: Buildings and populations

The thesis consists of six case studies (Papers I-VI). The basic material of five of them (Papers I-V) is made up by four study and three control buildings with their respective populations (Table 5). In the sixth study, the basic material is derived from the history, clinical examination and course of the disease of a single individual, while the building and its population, though dealt with, remain in the background.

Table 5. Buildings and populations

	Buildings		Populations	
Paper (I - VI)	Type	Built, year	N, adults	N, children
(I), study building I	Office	1979-80	85	-
(I), control buildings	Offices	1937, 1945, 1951	51	-
(II), study building II	Office	1982	23	-
(III), study building III	Office	1984-85	56	-
(IV), study building IV	School	1975	23	135
(V), study building III	Office	1984-85	56	-
(VI), study building V	School	1980	39	-

3.2 Sources of information

Multiple sources of information, containing quantitative as well as qualitative data, have been used, and were comprised - with the exception of the interviews - by historical documentation from different sources such as the local occupational health services (OSH), the Labour Inspectorate, individual employees, the local newspapers' archives, and others (Table 6).

Table 6. Sources of information used in the case study

Quantitative information	Qualitative information
*Symptom prevalence from health surveys performed by the local Occupational Safety & Health Services using the Örebro questionnaire (171), or, before 1991 similar surveys**	Minutes, notes, appeals and proclamations from meetings held by personnel. Minutes from municipal political boards concerned with planning, construction and environmental protection.**
*Building construction drawings.**	Messages and injunctions from the Labour Inspectorate***
	Social Security Office files regarding work indemnities.**
*Work environment investigations by the local OSH:s, the building owners and theirs consultants.**	*Patient files from the local Occupational Safety & Health Services***
Clinical chemical, physiological, immunological and radiological data.*****	Patient files from the local Public Health System**
	Material from local newspapers***
	Letters exchanged between employers, employees and proprietors.**
	Interviews with selections of persons who have worked in the buildings, or who had other relations to them.****

**Sources of information for all Papers*, **Sources only for Papers I, III, V, ***Sources only for Papers I-III, V, ****Sources only for Papers II, III, *****Sources only for Paper VI.

3.3 Case selections

The cases that form the bases for Papers I, IV and VI have not been selected according to principles or strategies which were defined beforehand. In this, their form of selection corresponds to the one found in so called "intrinsic casework" (161). The study building in Paper I was a municipal office with long standing non-specific health problems, and whose management solicited help from the local Occupational Health Service. The selection criteria of the three control buildings of this paper, however, were specifically defined and required the buildings to be municipal administrative offices built before 1955. The building of Paper IV was a public primary school with non-specific health problems, recurring also after repairs were effected, why assistance was solicited of the local Occupational Health Service. In both instances, the investigations were performed in order to gain a better understanding of the individual cases. It was hoped that such an understanding would lead to possible clues to the solutions of the on-going health problems. Thus, their appearance in the

thesis is the result of what one could call "problem-oriented auto-selection". This was also the selection principle of Paper VI, which focuses on a single individual, who became seriously ill while working in a school with non-specific symptoms attributed to the building.

Papers II, III and V, on the other hand, correspond to what has been classified as "instrumental casework" which is carried out to provide insight in some particular issue or to contribute to the refinement of its theory (161). Accordingly, the two buildings of these papers were specifically selected on the assumption that buildings with long-standing health problems would provide a rich and varied source of information on processes possibly leading to chronic health problems. The selection criteria were based on the longevity of symptom duration.

Whereas Papers I-IV deal with the buildings and their populations, Paper V, dealing with Building III, focuses on the diagnosis of SBS, and is based on three individuals with their non-specific symptoms legally recognised as work indemnities. The three individuals were selected because they represented two different lines of arguments used by the Social Security Office in its indemnity evaluation.

3.4 The interviews. Selection of informants

The purpose of the interviews was to provide a wide range of perspectives on the evolution of the building's health problems and the way in which those problems were handled over the years. Because of that, the selection of interview subjects was intentional rather than random (163), based on principles of non-probabilistic, purposeful sampling (159). The interviewees were selected to provide the broadest range of views on the start, evolution and handling of the buildings' health problems. The final range of interviewee perspectives is presented in Table 7.

The interviews were semi-structured (172) based on a loose pattern of open questions with focus on the buildings' histories up to their abandonment in 1996 as seen from the personal and professional experience of the respondents. The basic topics addressed were the first appearance of symptoms, their progress and management. The interviews were tape-recorded, transcribed and analysed. Every interview was first read in detail, and then again as a comprehensive entity. In essence, the procedure meant the repeated close search for recurrent patterns and regularities, which eventually were united into a number of themes. These were analysed in the light of, and integrated with, the information from the other data sources (Table 6).

Table 7. Range of interviewee perspectives covered by the interviewee selection

Perspective/view	Office, Paper II	Office, Paper III
Employee	Yes	Yes
Syndicate	Yes	No
Management	Yes	Yes
Proprietor	Yes	Yes
Gender	Yes	Yes
Work Environment Experts	Yes	Yes
Contract holder	No	Yes

3.5 Definitions

In the papers, the symptoms which repeatedly were registered in the prevalence studies have not been combined to define any particular ”Sick Building Syndrome” with the exception of Paper IV. There, the relevant individual building-related symptoms (Table 1) from the questionnaires were arranged in three groups: General symptoms, skin and mucous membrane symptoms. If at least one question from one of the three symptom groups was answered "yes, often", SBS was considered to be present. In the same paper, a subject who reported suffering from asthma, hay-fever or atopic dermatitis, previously or presently, was classified as atopic.

3.6 Statistical methods

With the exception of Paper IV, rates have been used only to describe prevalence by percentages. In Paper IV, rate ratios (RR) for SBS according to its given definition were also calculated from the prevalence rates, with 95 % confidence intervals (CI) according to Miettinen's test based method.

3.7 Analysis

Every single study, forming part of this thesis, was analysed as it appears in the respective paper (I-VI). The analytical strategy has been a form of ”pattern-matching”(158). By this is meant the comparison of an empirically based pattern with a predicted one. In papers I, II, III, IV, both bio-medical *and* psychogenetic/psychosocial models have served as patterns, in paper VI only a bio-medical one, and in paper V a systemic model, ”total building performance” was used. In this framework section of the thesis, the studies are treated jointly as a comprehensive multiple-case study (158), that is, as a collective casework (161). The analytical strategy remains unchanged, basically utilising three patterns.

3.7.1 The bio-medical pattern (model)

The bio-medical pattern (model) is the one most often advocated by SBS researchers, e.g. Menzies and Bourbeau (20) and Redlich et al. (15). It implies that the non-specific symptoms of SBS originate from exposures to physical factors released in the indoor air. Such factors could be dust, microbes, or chemical emissions. Water damaged building materials facilitate the emergence of some such factors (e.g. microbes, chemical decomposition of building material). Failure to identify and/or eliminate such factors is thought to lead to a building becoming chronically sick. Long-term exposure to such factors may lead to increased susceptibility in certain individuals, which in turn may result in some persons having continued symptoms, even after elimination of the suspected causal factors. A high prevalence of such individual susceptibility might also lead to a building becoming chronically sick.

3.7.2 Psychogenetic/Psychosocial patterns (models)

These patterns (models) imply that stress factors of different kinds can be responsible for the non-specific symptoms of SBS. First, it has been pointed out that environmental concerns, or perceived environmental threats have particular characteristics considered central to their psychological impact. Among these characteristics are: the invisibility of the environmental exposures, their potential transgenerational effects, the lack of undisputed knowledge about their health effects (with the consequent occurrence of conflicting messages about what to believe and how to behave (173,174)). Second, there are several potential stress factors in workplaces, for instance rigid organisations with high demands and poor individual decision

latitudes leading to job strain, or the presence/absence of job support, threats of unemployment, or the introduction of new technology (175).

There exists a substantial body of evidence demonstrating how psychosocial interactions in work environments, as well as in other situations, can cause symptoms and physical alterations including diseases along physiological pathways, involving neuroendocrine responses (175-178). The links between psychosocial processes and the SBS symptoms could be various. First, the processes may act directly as stressors, causing symptoms through psycho-physiological mechanisms. Further, they may render the individual more sensitive to physical and chemical factors, normally tolerated, in the environment. Continued, unresolved presence of stress-factors might lead to a building becoming chronically sick.

3.7.3 The systemic pattern (model)

One central aspect of systems theory is that every individual is an interactive part of a larger whole, meaning that to understand the different expressions of an individual, the observational and analytical perspectives have to shift from the individual to the different backgrounds, or contexts, and back again (179). No single, nor any single specific patterns of combined factors that lead to non-specific symptoms in individuals in specific buildings have been demonstrated (14,20). Rather, multiple environmental and psychosocial factors seem to interact in complicated patterns with social support, personality, susceptibility and building-external factors such as e.g. media coverage (33,53). For such reasons, Ford (95) advocates the opinion that syndromes such as SBS are best regarded as simultaneously being medical, psychological and social phenomena. He therefore suggests that they are best viewed from a systems theory perspective; *"that is to say, multiple factors interact to determine the final pathway of the symptom"* (95). It seems possible, then, that such analytical perspectives could enhance the understanding of sick buildings by disclosing possible unfavourable interactions within different parts of the system. If so, such disclosures might facilitate the elaboration of strategies for prevention, investigations and remedial actions.

4 RESULTS

4.1 The emergence of chronically sick buildings

4.1.1 Prevalence

In all cases (Papers I-VI), the encountered rates of relevant symptoms were in excess of 20 % among the adult populations, while well below that in the child population (Paper IV) and in the adult populations in the control offices (Paper I) as exemplified in Figure 1.

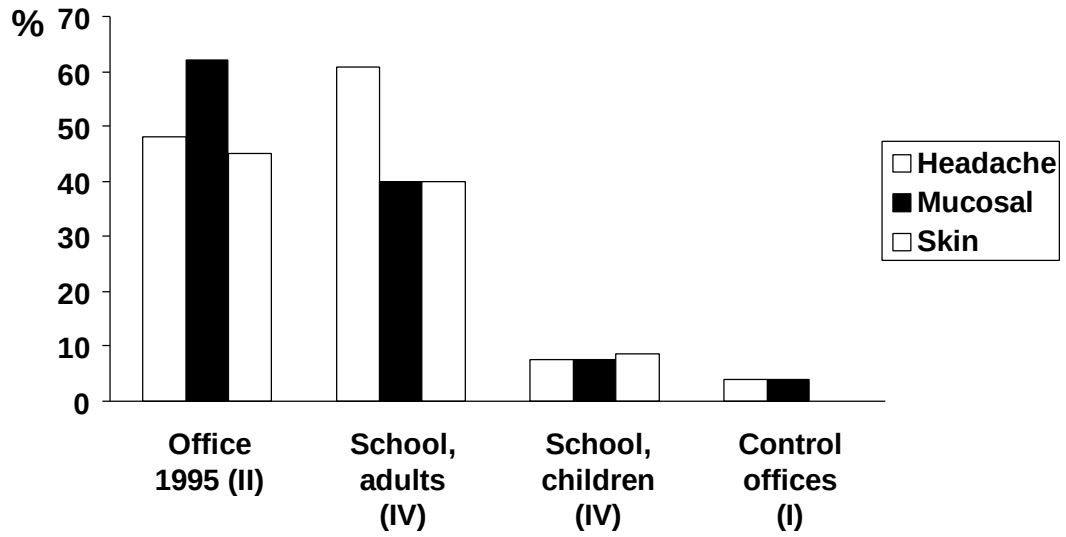

Figure 1. Prevalence rates, non-specific symptoms. Data from Papers I, II and IV.

4.1.2 The history of three offices

This is the story of health problems among the personnel in three medium size Swedish offices built in the 1980ies. In all three of them, there were substantial delays before the gradually evolving symptoms were recognised as being related to the buildings. Then, from the time of symptom recognition, the respective management acted rather similarly with hesitancy, vague and contradictory information on suspected causes, planned investigations, and encountered findings. In the local press, there were frequent, often inconsistent and sometimes speculative reports on different proposed causes, economic consequences of the problems and conflicts within the buildings (Papers I and III). Correspondence, minutes and notes from formal and informal meetings revealed an irritated atmosphere between employees, management and building proprietors

(Papers I-III). Different parties (e.g. employer, proprietor, consultants, occupational health services), involved in the investigations and repairs, worked with unclear responsibilities, resulting in ineffective mutual communications and the lack of integrated and comprehensive perspectives. Among the personnel, rumours increased concerning risks of future, serious harm as a consequence of work in the respective building. An opinion developed that the management ignored the symptoms. Actions and pronouncements by building-owners, employers and experts were interpreted as supporting that opinion. Because of this, at different times during the process, the personnel resorted to drastic measures (Table 8) in order to indicate the seriousness of their health problems.

Table 8. Papers I - III: The personnel's resort to drastic actions in order to get attention to the health problems in the buildings.

Building	Year	Action
Paper I	1981	Absolute guarantees for a safe work environment, otherwise sick leave on a mass scale
Paper I	1985	Emergency referral of all employees for specialist medical examination at a clinic 500 kms away
Paper II	1996	Health and safety union representative ordering closure of building
Paper III	1988	Appeals to political boards for immediate actions

4.1.3 The three offices: Investigations and remedial actions

Occupants of *Building I* (Table 9) suffered from health problems during two distinct periods. At first, no abnormalities could be demonstrated in the building. After almost two years with health problems, the building was evacuated. A consultant group then found an elevated humidity of the building's concrete foundation. The consultants assumed that this had resulted in the emission of gases from a casein-containing putty underneath the floor mats, which, reinforced by an insufficient ventilation, was thought to have caused the symptoms. Consequently, the putty was removed, the building dried, and the ventilation rebuilt. One and a half years after reoccupying the renovated building, symptoms suddenly reappeared. After a chain of events spanning half a year with repeated meetings, contradictory information, rumours and reports in the press, the building was again investigated, but this time no faults were found. After one year, the personnel transferred to other premises, and the symptoms disappeared.

The personnel in *Building II* (Table 9) reported non-specific symptoms from one year after the building's inauguration in 1982. Some years later, they were attributed to the building, and reported to the employer, who responded by having the ventilation system investigated in 1987, and again in 1989-90. As a consequence of this, the ventilation was reconstructed. Owing to continued reporting of symptoms, further investigations were carried out in 1994-95. This time, defects of the building drainage system were found, and parts of the concrete foundation also contained excess humidity. Glue beneath linoleum floor coverings was wet, and pipe passages between the floors were not tight, allowing the passage of air and possible contaminants between floors. It was suggested that the long-standing health problems probably were due to emissions from glue whose chemical decomposition was facilitated by the moisture underneath. Repairs, logically based on this suggestion, were undertaken while the building remained normally occupied. Symptom prevalence increased, why after four months the personnel were evacuated to another building. They returned when the repairs were finished. Two months later, symptoms started to be reported again. This led the proprietor to examine the ventilation tubes, assisted by workers using ventilation masks, while the office personnel were working as usual. Visible dust was spread in the building, leading the health and safety representative to close it (Table 8). It has not been used since.

The health problems in *Building III* (Table 9) also began one year after its inauguration. From 1987 and up until its closure in September 1996, numerous investigations of the building environment were performed. No co-ordination occurred among the investigators, nor those mandating the investigations. Reports were often incomplete, and rarely shared. Some defects in the ventilation system could be demonstrated, but in spite of the great number of investigations performed, no obvious, well defined abnormality which might explain the symptoms was found. Despite the fact that no prior faults were discovered, the inner floorings of all corridors were replaced in 1988, while the ventilation was rebuilt, including a separate system for the stairways. The office workers were evacuated during these renovations. In 1989, a consultant group was brought in because of persistent symptoms. They felt that the findings of their investigation permitted the retrospective deduction that the concrete foundation, albeit dry when investigated in 1989, had been sufficiently wet some years earlier to cause the emission of gases from glue and putty underneath the floor mats. This deduction led to the replacement in 1989-90 of the original PVC mats with non-glued linoleum mats in all rooms. However, the symptoms continued, and when the same consultant group made a new investigation in 1995, they could come to no conclusions. Again, without the demonstration of prior faults, the building was evacuated and another,

completely new ventilation system was installed. Upon re-occupation, symptoms returned, and in 1996 the building was permanently abandoned.

Table 9. Summary of investigation findings, remedial actions and SBS outcome

Building	SBS	Faults upon investigation	Hypothesis	Rational repair relative the hypothesis	SBS persists after repair
Building: I					
Episode 1	August 1980 to February 1982	Water damage, casein putty, insufficient ventilation	Chemical emissions	Yes	Recurred in 1984
Episode 2	November 1984 to December 1985	None found	None	?	Personnel moved to another office
Building II	1985 - 1996	Drainage partially defect, partially high moisture content in foundation, decomposed glue	Chemical emissions, after repair none	Yes	Recurred
Building III	1986 - 1996	Some ventilation defects	Chemical emissions 1989, none in 1995	Yes ??	Yes, all the time

4.1.4 Interviews

In both Building II and III, the interviews conveyed a picture of a long history of unresolved health problems. Five recurrent themes emerged - all related to the extended process of symptom development - and are listed below, illustrated by some quotations. All five were prominent in Building III, two of them in Building II.

- **Conflict** (Building III)
  "We all had different interests to look after, there were many reasons for conflict, hostility and, say, territorial fights"
- **Credibility/trust** (Buildings II and III)
  "They have done something all the time. Changed fans, torn floors up, something here, something there. We've had questionnaires over and over again, but nothing changed, and, finally, you asked yourself; do they really do anything?"
- **Economy** (Buildings II and III)
  "I think it is money that governs them, it is like they look at the costs, and then they say, let's try that, if it works, then fine."

- **Gender** (Building III)
  ”They have been dribbling for ten years, and done this and that, but basically all the time they have thought it was female nonsense.”
- **Systematic** (Building III)
  ”and they have measured and measured, and said this and that, but you never really know what they said, and it was as if they never saw to the totality, to the building as such.”

From the way the recurrent patterns were literally phrased, it seemed as if they were related, or could be considered to be related, as determinants in an hierarchical order with *economy* and *gender* in the first level (Figure 2).

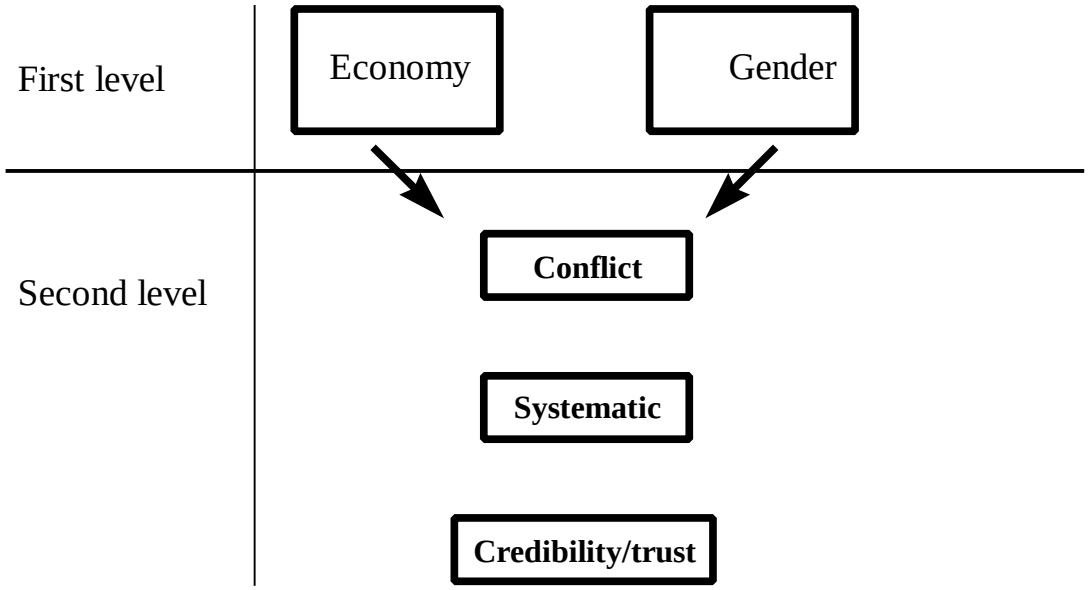

Figure 2. A suggested hierarchical order of determinants for the processes within the building

Thus, it seemed as if economic and gender perspectives influenced, or governed, the second level themes, i.e. the degree of conflict development and the levels of credibility or trust within the building, as well as to which extent systematic investigative procedures were undertaken.

4.1.5 The primary school

In a school (Paper IV) built in 1975, the teachers began reporting the following symptoms in 1985: headache, fatigue, irritation of skin, eyes, nose and throat. An investigation revealed an under-sized ventilation and an increased moisture content in the floors' concrete layer. Extensive measures were taken, whereupon the symptoms disappeared, only to return some years later. This time some minor defects were found in the building, and dealt with. Symptoms nevertheless persisted, and the teachers grew increasingly concerned. The worry was underlined by the transfer of two teachers to other jobs because of symptoms. Much of the anxiety was also focused on a former teacher whose child developed allergic manifestations, which by rumour, were attributed to the mother having worked at the school during her pregnancy. New, extensive investigations of the building were performed in 1990-91. Nothing abnormal was found. However, an investigation demonstrated a high prevalence of symptoms for the adult personnel and a significantly lower one for the children (Figure 1). The children who presented SBS associated symptoms were mostly atopic (Table 10).

Table 10. Prevalence of SBS symptoms in elementary school pupils with and without atopy.

Children	SBS		Not SBS	
(N = 103*)	n	%	n	%
Atopy	12	31	27	69
Not atopy	7	11	57	89

*Information concerning atopy is lacking for one of the children

The pronounced difference in symptom prevalence between the children and the adults was attributed to the fact that primary school children are not as aware as adults of the debate, media focus and anxiety concerning local sick buildings. Therefore, their reporting of symptoms would be fairly independent of such attention. Accordingly, the difference in prevalence might indicate psychological mechanisms leading to a "response bias" in the teachers, who from previous experience of the problem were aware of the hypothesis ("the building is sick"), the local debate, other sick buildings in the community, and local rumours. This does not mean that merely psychological effects leading to bias can be considered the basis for the high prevalence. The fact that most of the few children for whom SBS was reported (Table 10) were atopic suggested that physical factors also might play a role.

4.2 Constructions of building-related diagnoses

4.2.1 SBS: a diagnostic dilemma

In the office of Paper V, the workers filed claims to the Social Security Office (Table 11) that their non-specific symptoms were caused by the work environment, and therefore should be considered as work indemnities.

Table 11. Number and outcome of claims for work indemnity due to non-specific building-related symptoms in the case building

Year	Number of claimants for work indemnity	Number of claims later approved by the Social Security	Number of claims disapproved
1987	9	8	1
1988	5	3	2
1989	2	1	1
1990	-	-	-
1991	2	1	1
1992	-	-	-
Jan - June 1993	4	1	3

There is, however, a diagnostic dilemma inherent in the definition of SBS. While the usual medical syndrome is constituted by groups of signs and symptoms forming a clinical picture of disease in individuals (180,181), the sick building syndrome is regarded as being present when certain non-specific symptoms are present at a prevalence that exceeds that normally expected in a building population (15,16). Indeed, with such a definition it is rather the system, i.e. *the building inclusive of its population*, that is afflicted by the syndrome. Therefore, it seems likely that the term SBS never was intended to be used in the diagnosis of individual persons, though in fact it is. Proposed individual diagnostic procedures are vague, but generally include the exclusion of other conditions, the improvement of symptoms when the patient is temporarily removed from the workplace, and the requirement of clusters of other cases in the subject's building environment (15,26,32). However, such procedures do not resolve the fundamental problems in the use of SBS as an individual diagnosis, e.g. that persons applying for indemnity because of SBS basically ask for disability without evidence of impairment (182).

4.2.2 Resolving the diagnostic dilemma

In spite of this, the Social Security Office made determinations suggesting that the non-specific symptoms reported by the analysed claimants should legally be considered as work-related injuries. The justification was vague, with the term SBS being introduced and handled in two different ways. In one of the cases, the Social Security Office made a reference to SBS in such a way that it appeared as though it considered the constellation of symptoms *to be* a disease entity called SBS. In the two other cases on the other hand, the reference was made as if the constellations of symptoms *were caused by* SBS. Thus, in the latter cases it appeared as if the Social Security Office considered SBS as something that afflicted the building with the potential of causing disease, while in the former case it seemed to consider it as an individual disease. These two different views probably reflect the fact that the SBS definition, being dualistic, is unusually complex. It contains both outcome (symptoms) and exposure (building), with both an individual aspect (the affected person) and a collective one (the population). In the construction of an individual, person-based diagnosis such dualism has to be avoided. The Social Security Office attempted to do this, albeit differently between the cases. However, even though their justifications were indeed inconsistent and vague, the administrative and legal nature of the decisions implies an official recognition of SBS, suggesting a sort of rigour to the diagnosis. This conveys the ambiguous notion of SBS as a formal, individual diagnosis, which, like other medical labels of classification (183), can have a normative and prescriptive force. Thereby it might contribute to a process which inadvertently may serve to maintain, reinforce and render chronic the non-specific health problems of a building (Figure 3).

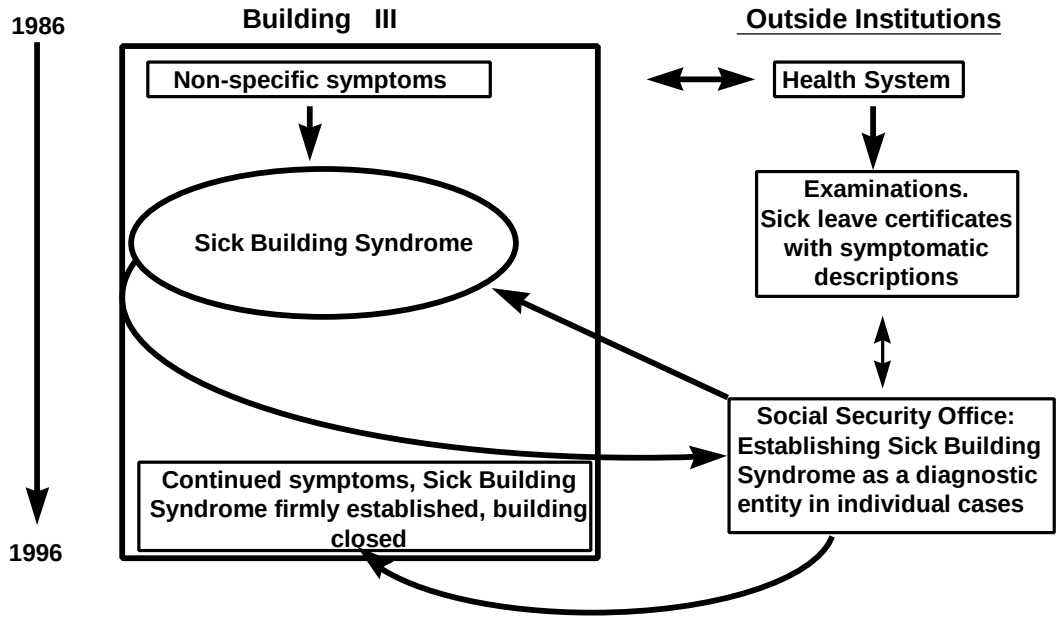

Figure 3. From diffuse symptoms to legally recognised syndrome

4.2.3 BRI: Allergic alveolitis - an individual diagnosis

In the school of Paper VI, water leakage through the roof had occurred repeatedly since the early 1980s. An unpleasant odour was often felt indoors, and at times a large percentage of the personnel experienced diffuse, non-specific symptoms. On September 1, 1988 one of the teachers suddenly had serious symptoms of the lungs. The disease state was first interpreted as an acute pulmonary embolism, though later was revised to an atypical case of sarcoidosis. Over the next six years the disease progressed with low-grade symptoms to a state of seriously impaired lung function.

In late 1994, the diagnosis was revised again to chronic allergic alveolitis, probably caused by massive exposure to mould in the school at the beginning of the 1988 fall term, and thereafter maintained by constant, albeit reduced, mould exposure over the next six years of work at the school. The case illustrates the difficulties in diagnosing allergic alveolitis, especially when the disease, as in this case, occurs in environments where it is ordinarily not found. However, in spite of these difficulties, the diagnostic criteria of this BRI are solidly based on a subjective disease history combined with a number of quantitatively and/or qualitatively well assessed objective laboratory tests from the fields of chemistry, immunology, cytology, radiology and physiology (129,130,132).

4.2.4 Constructions of diagnoses: SBS and BRI in comparison

The procedures of diagnosis are radically different between SBS and BRI, here exemplified by allergic alveolitis. Like any other diagnosis, both are in a sense social constructions. However, the construction of diagnoses within the BRI-group is largely based on concepts (criteria) which have biologically, demonstrable and reproducible foundations, while, on the other hand, SBS lacks all such bases. In addition, and different from the constructions of all other diagnoses, SBS does not exclusively involve aspects related to an affected individual person. It also involves collective aspects related to a building, a population and its prevalence of symptoms.

Table 12. Diagnostic criteria: SBS and BRI (exemplified by allergic alveolitis)

Criteria	Sick Building Syndrome (Papers I - V)	Allergic alveolitis (Paper VI)
Symptoms	Yes	Yes
Exclusion of other causes to the symptoms	Yes	Yes
Symptoms clustering among inhabitants or colleagues, or in excess of 15 - 20 %	Yes	No
Temporal pattern of occurrence in relation to determined buildings	Yes (according to some definitions) No (according to other definitions)	Yes (the acute form) No (the chronic form)
Evidence of exposure to relevant antigen	No	Yes
Radiology	No	Yes
Immunology	No	Yes
Physiology	No	Yes
Other laboratory tests	No	Yes

The differences, compared in Table 12, between the two constructions are important. It is the presence of individually related, biologically demonstrable criteria that permits both the positive identification of a case of allergic alveolitis, as well as the exclusion of other diagnoses, eg. pneumonia or flu, as the reason for the symptoms (fever, cough, dyspnea). In fact, the presence of such criteria constitutes the very basis for the diagnostic distinctions which are necessary for the choice of adequate therapeutic and preventive strategies, legal considerations, and for the execution of epidemiological studies. In general, the conceptual backgrounds of medical diagnoses are very complicated (184,185) and sometimes they lead to confused diagnostic practices. However, it seems clear that the BRI

(e.g. allergic alveolitis) form of diagnostic construction has a solidity or rigour which SBS completely lacks. The construction of the latter is such that its separation from other similar non-specific conditions in reality is impossible. This is noticeable in the few studies which have addressed both SBS and multiple chemical sensitivity or chronic fatigue syndrome (186,187,188).

4.3 The resulting construction of models

4.3.1 The emergence of chronically sick buildings

Common to the cases was the fact that symptoms developed within a context often involving vague and contradictory information, unclear responsibilities, ineffective, contra-productive organisations, delayed, hesitant, unsystematic and sometimes clumsily realised remedial actions, accusations and recriminations, rumours, drastic actions and speculative media reports, all contributing to a climate of depression, despair, distrust and reduced credibility within the buildings. The thesis suggests that important reasons for the persistence/recurrence of SBS were attributable to this climate which appeared to promote, reinforce and maintain symptoms, which in some cases originally could have been prompted by chemical emissions facilitated by water damage.

In the light of this background, it could be postulated that in cases of SBS, physical factors (e.g. moisture, unknown chemical emissions from putty) initially might give rise to symptoms. It could also be postulated that a variable complex of non-physical factors, e.g. conflicting agendas between owners of buildings, employers and employees, may lead to the intensification and maintenance of the symptoms (see Figure 2 in Paper IV). The physical and non-physical factors are proposed to interact in terms of symptom development. Their respective significance for the occurrence of symptoms varies from event to event, time to time, and between cases. For instance, in paper III where clear physical faults compatible with ”the moisture-emission hypothesis” could never be demonstrated, the non-physical factors are thought to have played a dominant role all years. On the other hand, in paper II, demonstrable, substantial, specific defects in the building structure were found, which made it reasonable to suspect them as important causes of the health problems (20,92). In this case, non-physical factors probably did not play a prominent role until towards the last year of the building history, and also then in continued combination with physical factors.

This interactive process of symptom development seems to be situated within a dynamic context of forces, to some extent determinant for the long-term outcome of the building's disease history. It appears (Figure 4), as if the disposition towards remedial actions is increased by certain forces, e.g. legislation and Labour Union, while decreased by others, such as costs and gender (189). At the same time, complicated internal organisational relations may lead to a fractured "remedial" structure, resulting in the lack of an integrated, comprehensive perspective and systematic work procedure. The end result is a process eventually leading to symptom preservation. Additional factors contributing to this process appear in Figure 3.

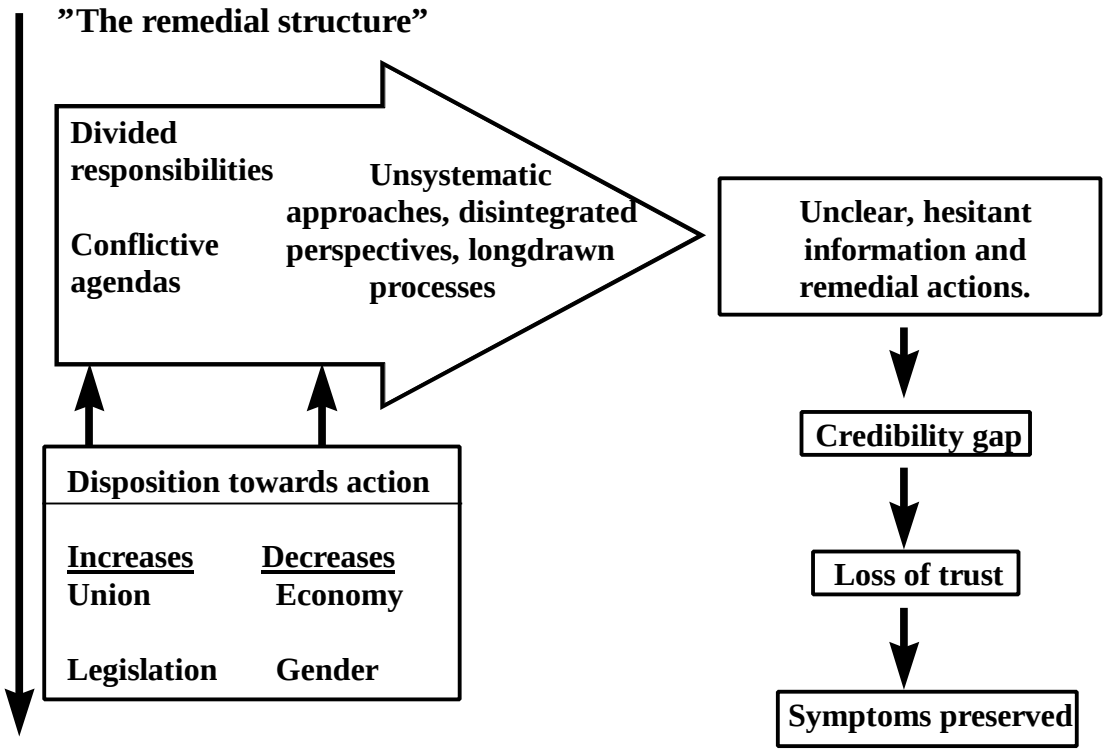

Figure 4. Influence of stuctural forces on the generation of sick building syndrome

In Figure 5, a schematic representation is proposed of the processes through which the links between symptoms generated and/or maintained by physical factors on the one hand and non-physical ones on the other can be seen to interact. It relies on certain similarities between so-called MPI (mass psychogenic illness) and SBS (119,120,190): the common occurrence of fatigue, difficulty in concentration, headache, nausea and skin flush in both conditions. However, MPI is spread epidemically (119,190-192), whereas SBS has a more endemic course (22,190). Nevertheless, a model used to explain the patho-physiology of the epidemic MPI (192) may also be

used attempting to explain the more endemic SBS. In Figure 5, this is done in combination with another patho-physiological model, which claims that the diverse SBS symptoms are caused by an imbalance in the sensory perception of complex environmental exposures (123). The combined model implies that a multisensory perception of low, often non-identifiable, exposures (possibly resulting from water damaged building materials) could lead to an excitation of the autonomic nervous system resulting in a higher degree of perception, tension and anxiety (118). The thus triggered symptoms may then be interpreted within the frameworks of general beliefs and experiences in the building in question, leading to reinforcement of the autonomic activation.

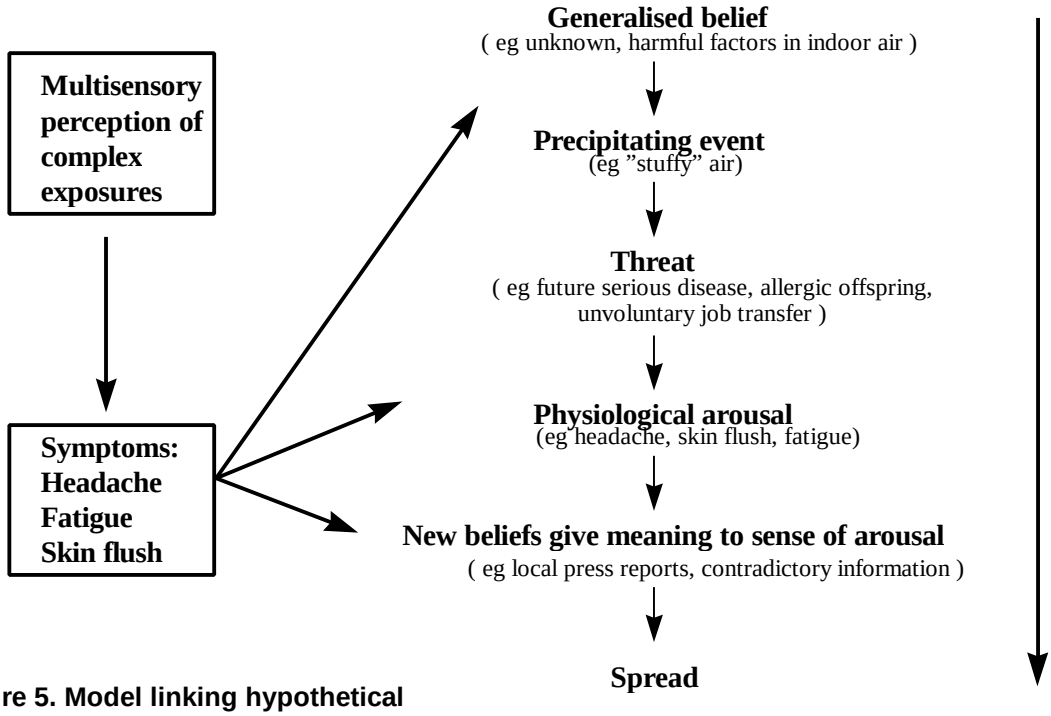

Figure 5. Model linking hypothetical mechanisms for SBS development
(modified after Olkinuora,(192) Berglund and Lindvall(124))

4.3.2 The systems theory model

It appears that the combined use of bio-medical and psychosocial models makes the emergence and preservation of the sick building syndrome more understandable than the models do separately. However, the thesis also demonstrates that there were not only interactions *within* the building system, but also between the building system and the surrounding world. For instance, with their formal handling of work indemnity cases the authorities like the Social Security Office conferred a certain legitimacy (Figure 3), while the Labour Inspectorate played a role by "deciding" that

there existed a sick building syndrome (Paper III). A number of consultants and experts were involved in different ways with the cases, and contributed, as did media, to shaping at times conflicting perceptions of the origins of the on-going problems (Paper I, Paper III). These interactions between circumstances pertaining strictly to the building system on the one hand, and the surrounding world on the other, suggest that the combined bio-psycho-social analytical model should be inserted in a systems theoretical perspective in order to further enhance the understanding of SBS development.

Figure 6 illustrates such a model with three principal levels of interaction. The first, within which the two others are situated, consists of the present historical, cultural and social environment. This level implies the existence of structures and values, e.g. economic and gender perspectives, which exert an influence over e.g. the development of conflicts and the degree of systematic application of remedial strategies (see e.g. Figure 2). It also indicates the existence of a historically determined framework for the interpretation of bodily symptoms (193,194). The second level of the model consists of institutions outside of the building system, e.g. health system, legislation, media, unions, individual experts etc. Finally, the third level consists of the building as such, including its population, work organisation and administrative conditions. All kinds of interactions between the different levels are feasible.

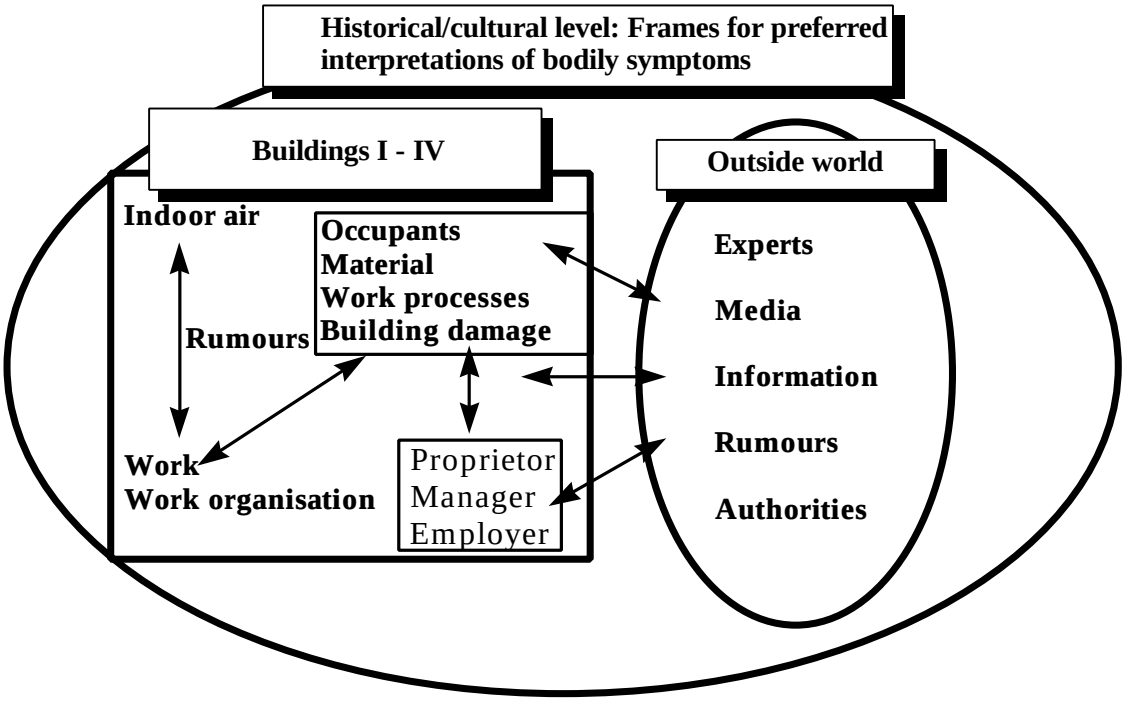

Figure 6. Integration of models:
Sketch over some levels of interactions.

4.4 The practical handling of SBS buildings

Generally, the bio-medical perspective dominates the practical dealing with buildings where non-specific health problems are reported. Removing identified, bio-medically conceptualised suspected causative factors does, however, not regularly reduce the prevalence or severity of SBS symptoms (195). Maintaining the strict bio-medical perspective, the perseverance of symptoms might be due to continued unrecognised exposure, or to self-perpetuating processes triggered by the unknown original insult (187).

However, the results of the thesis suggest that a bio-psycho-social perspective is the most adequate to explain the emergence and preservation of sick building syndrome. They even suggest (Paper II) that neglect of the psycho-social dimension could lead to a building becoming chronically sick, in spite of, from a biomedical perspective, rational, remedial actions. Consequently, also in the practical handling of cases of sick building syndromes, a holistic perspective ought to be used for the elaboration of preventive and remedial actions. There is no single SBS universe. Just like individual patients presenting non-specific symptoms in general (196), each single case of SBS (that is, the building *inclusive* of its population with an increased prevalence of non-specific symptoms) should be assessed and addressed individually, from the perspective of multiple aetiological factors (Table 13).

Table 13. Example of a holistic approach to the formulation of remedial strategies for cases of sick buildings (Modified after Sharpe and Wessely, 1997)

	Predisposing factors in the building population	Precipitating factors	Perpetuating factors
Biological	Individual constitution	Pollutants (insufficient ventilation, moisture, emissions from material)	Pathophysiological processes, continued presence of pollutants
Psychological and behavioural	Life styles, modes of thinking, experience of illness, cultural patterns of interpretations of bodily symptoms	Stress, media	Belief in disease, fear of disease, media coverage, work indemnity, professional attitudes
Social	Organisation, quality of relationships, local labour markets, cultural patterns of interpretations of bodily symptoms	Conflict, stress, relation problems	Reinforcement of sick role, ongoing stress, fractured organisations, in-comprehensive information

Such an approach should aim at the concomitant identification of possible predisposing, precipitating and perpetuating factors within all sub-spheres of the bio-psycho-social perspective. From the results of the present thesis this would mean that:

- One should strive for a co-ordinated remedial organisation;
- Proposed investigations should be rationally motivated, and systematically executed;
- Channels of information between different involved parties (proprietor, employer, employee, consultants, health organisations, authorities) ought to be unequivocal and open to all concerned persons;
- Results of investigations as well as of their interpretations should be clearly communicated;
- Encountered physical defects (ventilation, supposed emissions, water damage (20,92)) in the building structure should be dealt with in such ways that the actions remain credible.

5 GENERAL DISCUSSION

In this section, the validity, or trustworthiness (163), of the thesis will be commented on. It is then compared with previously published works. In a sense, this comparison also touches validity issues. After this, possible reasons for why SBS first appeared in the 1970ies, and became established in the decades that followed, will be discussed.

5.1 Findings: Trustworthiness

5.1.1 The context of the thesis

This research has been carried out in intervals during a very long time period. It started in 1985 with the questionnaire-based health survey of the populations of the study and control buildings of Paper I. The last active collection of information for the thesis was done in the fall of 1997, when the Social Security's files on the work indemnity cases of Paper V were retrieved. During all these years, in my daily work I have also been in frequent contacts with individuals suffering from non-specific symptoms attributed to buildings, as well as with entire buildings which have been referred to my work unit as being sick. The experiences of these contacts, as well as of the accumulated international research on the subject, have resulted in many discussions with professionals as well as with laymen concerned by this issue. The discussions, as well as my own frequent reflections on the subject, have almost always concerned the question: "why SBS?" And the tentative answers have oscillated from those with their roots in bio-medical models to those with their roots in psychosocial ones. Both models have continuously competed for attention as interpretative patterns.

5.1.2 Triangulation and alternative interpretations

Among the methods which are commonly recommended as useful in estimating the trustworthiness of a qualitative work, such as e.g case studies, is a technique called "triangulation" (159,169,197). In essence, it consists of the combined use of different methods, of different data sources, of different theories or of different observers (169). In this thesis, and to a variable degree between the papers, three different sources of information (Table 6) were used; historical documents of the most varied sort;

questionnaire-based health surveys (Papers I-VI) including control populations (Paper I); and, finally, semi-structured interviews with open questions (Papers II and III). When analysed, data from the distinct sources converged to a consistent pattern of a symptom development- and preservation within a building system marked by complicated and sometimes conflicting interactions and communication. This convergence is thought to enhance the study's trustworthiness.

The use of different theoretical models as the basis for the pattern-matching (158) was another form of triangulation; triangulation of theories (198). The distinct models served as alternative interpretative frameworks, and provided the opportunity to test rival interpretations of the findings; e.g. bio-medical models vs. psychological/psycho-social ones. It seemed as if neither of these models alone could provide a credible interpretation. However, when combined they did so. Also, it seemed as if the credibility was further enhanced when a systems theory perspective was applied.

5.1.3 Selections. Transferability-generalisability

The selection of literature on the topic sick building syndrome and related matters has been exhaustive, and I believe its presentation in this thesis is comprehensive and representative. Also, it was the ambition to get hold of all possible existent documentary sources of information on the buildings' health problems (Table 6). Possibly, some sources have nevertheless been missed. However, all those, which were retrieved, were reviewed and included.

None of the buildings were selected as a statistical sample. Three of them (Papers I, IV and VI) were not chosen at all - they were pre-specified as cases of prominent interest (161). The two other case buildings (Buildings II and III), were, on the other hand, purposefully selected based on the criterion of having very long-standing health problems, and were, in fact, the only buildings in the region fulfilling the required criteria. For the interviews, the guiding principle for the selection of informants was likewise purposeful with the intention to get as wide as possible range of perspectives regarding the studied phenomenon; that is the development and handling over the years of the buildings' health problems. The purposeful selection means that it is not possible to generalise the findings to populations in statistical ways (158,199). In stead, depending on the degree of trustworthiness, the findings might be generalised in relation to theoretical propositions, so called "analytical generalisation" (158). That is, generalisations may be made on the basis of a study's capacity to formulate coherent structures which explain the diversities of its findings (199). If the

data/ information produced by a case-study is consistent, dependable and presented in a form where it is open to multiple interpretations, then a full and thorough knowledge of the particular case might allow one to see similarities in new and unfamiliar environments and events (159). A study which allows this would have at least a minimum measure of, respectively, ”communicative” and ”pragmatic” validity, which are important components of the trustworthiness of case-studies (159,165,197,200).

It is believed that this thesis has been presented in such a transparent way that it has maintained a visible chain of evidence. It is also believed that the findings are sufficiently understandable and conceptually clear to permit their transmission to other settings of long-standing building-related health problems. If so, their transmission and translation into strategies and programmes for how to prevent and handle such health problems would subsequently, by their practical results, demonstrate the degree of pragmatic validity.

5.2 Comparison with other studies

There are important differences between the quantitative procedures generally used in SBS studies, and the dominantly, qualitative ones applied in the present thesis. Therefore, a comparison of the two distinct methods is important. It might serve to contrast their respective strengths and weaknesses in relation to the study of non-specific symptomatic syndromes such as SBS. Such a comparison does not imply that there exists any polarisation between the two types of methodologies. Rather, they should be seen as complementary ways of study designs (157,201).

5.2.1 Choices of methods in comparison

The quality of a study is dependent on the questions raised, and on the study design and methods chosen to respond to those questions (166). Qualitative methods are best suited to areas that have received little previous investigation, or those which are poorly understood, or ill defined (154,157,202). They are most appropriate in situations where independent variables producing the suspected outcomes are not apparent (157), when the researcher’s control over the situation is limited (156,159), and when the questions posed are *”what”*, *”how”* and *”why”* (158,201,202). On the other hand, quantitative methods are most appropriate in defined and limited

contexts where independent variables can be specified and their effects on an outcome subsequently can be studied (157).

The adequacy and potential usefulness of the respective methods in the study of the sick building syndrome should be evaluated on the basis of these different methodological characteristics. SBS is an outcome, which, consisting of the increased prevalence of constellations of non-specific subjective symptoms in determined buildings (commonly occurring among general populations (41)), lacks demonstrable biological markers (18,19,25). The factors (independent variables) thought to influence this outcome are not specified, but suspected to reside in a potential multitude of constellations of unknown circumstances, chemical, physical, psycho-social, organisational and other factors, originating in the building system and inclusive of its population and of the work environments within the building. Given this background it seems as if the choice of qualitative methods in the study of SBS would be preferable to the choice of quantitative methodologies.

5.2.2 Preconceptions and objectivity in comparison

Quantitative methods are more formalised and structured than qualitative ones. They define in advance which conditions are of particular interest for the chosen research questions, and anticipate which variation of answers could be found (203). The design is characterised by distance and selectivity in relation to the information sources (197,203). Qualitative methods, on the other hand, are characterised by flexibility, closeness and sensitivity in relation to the information sources (197,203). While this is the major advantage of the method, it is also a potential source of serious bias. In order to minimise this, a number of procedures has been developed, and some of these have been described.

Quantitative methods also suffer from different sorts of bias. However, their formal structure with their accompanying rules has been designed to safeguard objectivity. It is often considered that this formal structure with pre-defined concepts, procedures and the use of inanimate instruments to study unfamiliar settings minimises researcher preconceptions that could bias findings. Nevertheless, it has also been pointed out that in all research, interpretations are made in relation to pre-existent knowledge and concepts (157,204).

In the study of non-specific symptomatic syndromes which lack demonstrable signs and biological markers, practically all quantitative research results are based on the validity of self-reports (33). Previously in

this thesis, a number of serious validity problems related to the epidemiological study of this type of syndromes was reviewed. To those problems could be added that in such study areas, it might be particularly difficult to uphold the quantitative procedure's formal requirements of distance and pre-definitions. This can be illustrated by a comparison of the definition of cases of SBS in epidemiological studies on the one hand, and in the present thesis on the other.

In the thesis, the definitions of cases had already been done before the study even was contemplated, e.g. as in the building of Paper III and V. There, for several years, the non-specific symptoms had been attributed to the building and named SBS by its users, by media, by the health system, by the Social Security and by the Labour Inspectorate. In fact, the building was selected just because of having had long-standing non-specific, building-related health problems, and the interest of the study was to see how and why these SBS-cases, *solidly defined by praxis*, developed and persisted.

On the other hand, in epidemiological studies working with randomly sampled buildings (4,23), the distance inhibits the identification of such robust and praxis-defined cases. In stead, the *cases are defined in advance by the researchers*. In order to stick to the formal procedure of the chosen design, to its rules of distance and claims to objectivity, the definition, once made, should not be changed. However, its abstract character as a pure researcher construction makes change possible, and, in fact, sometimes it is changed retrospectively, which, for different reasons, Ooi et al. (23) and Sundell (4) demonstrate in their studies. Such departures from the formal structure of the quantitative procedure, do not necessarily invalidate the results of a study. However, they do demonstrate the existence of some kind of researcher preconception, reducing, in the context of this study area, the quantitative procedure's claim to objectivity. Furthermore, they illustrate, again, the important distinction between the construction of definitions of purely subjective syndromes such as SBS on the one hand, and of syndromes/diseases such as those of the BRI group, for instance allergic alveolitis (Paper VI), on the other. In the latter group, the presence of demonstrable signs and measurable biologic markers preclude major changes of case definitions.

5.2.3 Findings in comparison

Paper V involved a study of the definition of SBS, and of its application as an individual diagnostic concept. Although this particular issue was not specifically studied, a number of review articles (14,20,35,37) and

dissertations (36,93) discuss problems with definitions. All of them argue in favour of the abandonment of the concept in favour of other definitions, and thus come to the same conclusion as Paper V.

Owing to the use of different methods, direct comparisons between the results of the majority of the works on SBS and the ones of the present thesis are extremely difficult. Nonetheless, several epidemiological studies have demonstrated associations between SBS-symptoms and ventilation parameters (15,19) and water damage (81,109). It is commonly thought that these associations are indirect expressions of variable exposures to unknown chemicals thought to contribute to the generation of symptoms (20). Such associations are compatible with findings encountered in some, but not all, periods of the long histories of some of the cases (Paper I, Paper II and Paper IV). Several epidemiological studies also demonstrate statistical associations between psycho-social factors and the prevalence of SBS symptoms (84,86,93,121,205). These results, although very general, are in agreement with the present study's more specifically detailed findings of the emergence of conflicts, states of reduced credibility, despair and depression in buildings with long-standing non-specific health problems.

5.2.4 The SBS stage: Methods in interplay

Among different epidemiological studies, the SBS symptoms vary considerably. There are large differences in prevalence rates, as well as different patterns of symptom combinations. It has been claimed that this is due to a wide range in the threshold of response (susceptibility) in any population, to the possibility of a variety of responses to any given agent, and to variations in exposure within large office buildings (20). It has also been proposed that this variability could depend on the existence of different sub-syndromes of SBS (93) caused by different combinations of stress factors. Basically, these claims are identical and imply that there exist relatively stable variations of different SBS outcomes, owing to a variety of specific, albeit presently not known, bio-medical micro-environments and/or different combinations of psychosocial stressors. A comprehensive review of the literature on SBS demonstrates, however, that there are no strong reasons to believe that there exists a strict sick building syndrome universe (syndromes or sub-syndromes). The results of the present thesis support that view. They suggest that every building case is specific; that is, unique in its development of SBS within a dynamic, complex, variable and interactive context. It thus appears as if the more specific, varied and detailed results of the present thesis (Papers I-VI) are

compatible with the more general results of the epidemiological studies as illustrated in Figure 7.

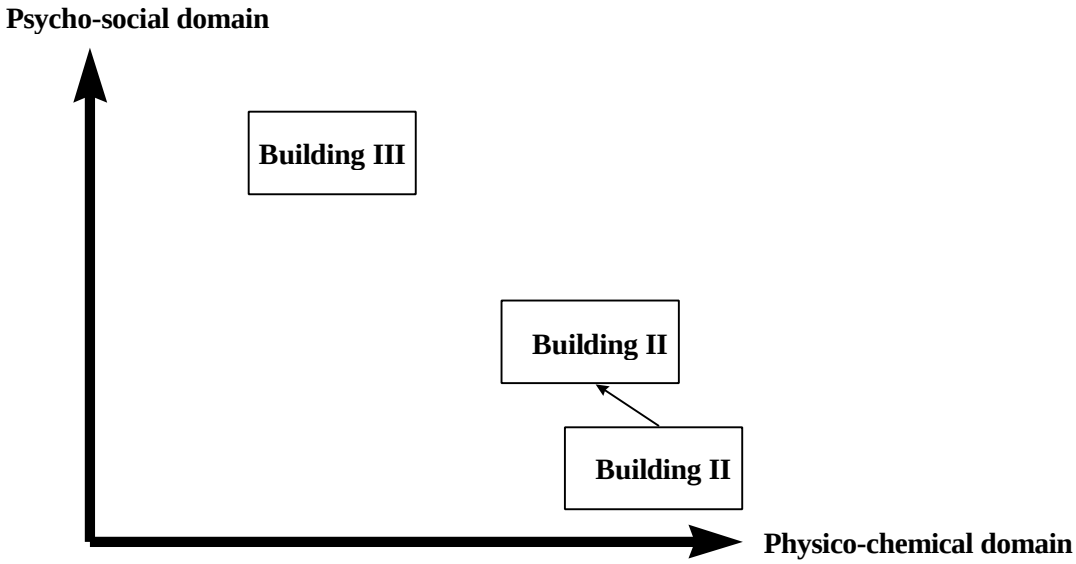

Figure 7. Cases moving on an epidemiological stage

The epidemiological studies identify psycho-social (y-axis) and physico-chemical (x-axis) domains involved in SBS development. However, the general and overview nature of the information they generate limits their contribution to the understanding of why and how long-standing cases of SBS develop. They give few clues regarding the practical handling of SBS cases (145), and fail to uncover dynamic processes involved in the development of SBS. They might, however, be seen as studies which set the outer limits (x- and y-axes) of the stage on and over which the real-world cases of sick buildings develop and move around. The detailed investigation of these cases facilitates, on the other hand, the identification of case-specific dynamic processes involving several concerned parties within and outside of buildings. By this, they render the development towards chronicity more understandable, and can, within the limits set by the epidemiological studies, contribute to the elaboration of practical strategies for prevention and treatment of building-related health problems.

5.3 Why SBS now?

5.3.1 *Energy crisis, new materials, end of the industrial era*

The emergence and increase of the SBS prevalence is generally considered related to three factors:

1) The energy crisis in the 1970-ies, and the consequent strive for better insulated buildings in order to conserve energy;
2) Concurrently, the use of new and synthetic building materials increased. These compounds emit various substances (many of which are not identified) some of which are thought to contribute to symptom development;
3) Concurrently, there has been a substantial increase in the absolute as well as relative number of workers employed in the different service sectors, resulting in an increase in the exposed population.

Many of the findings of the thesis are in agreement with the two first factors. For instance, in Paper I, the first SBS-episode was related to water damage, poor ventilation and the decomposition of a levelling putty, and in Paper II similar conditions were demonstrated upon investigation.

5.3.2 *Modern age diseases: society, stress, attributions?*

The characteristics of SBS, non-specific symptoms and at the same time the absence of demonstrable pathological alterations, are shared with other health problems which have also emerged during the last, few decades, e.g. ”multiple chemical sensitivity”, ”electric hypersensitivity”, ”oral galvanism” and ”repetitive strain injury” (206). Sometimes these labels for groups of non-specific symptom are collectively denominated ”modern age diseases”, raising the question as to whether their occurrence in the second half of the 20th century could be related to stress due to the rapid changes of work organisations, social security ideologies, job insecurity and increased efficiency demands (207). Such general societal stress could be interacting with the presumed stress of the internally conflicting and complicated situations in, for instance, Papers I and III. However, in addition to the increased and evolving nature of societal stress, there may also be other society-specific, cultural and sociological phenomenon which might explain why the modern age diseases are diseases of today.

One important phenomenon is the attribution pattern. It has been demonstrated that non-specific symptoms at different historical times are interpreted differently and to a certain extent also are responses to time-specific needs (208,209). Further, historical research indicates that constellations of such symptoms are attributed to different causes reflected

in the designations given to them (193). It also demonstrates that the attributions evolve in an interplay between contemporary ideas, beliefs and knowledge within and without the medical community (193,210). Currently, designations such as "multiple chemical sensitivity" (210), "electric hypersensitivity" (211) and "sick building syndrome" (95) are often used, suggesting environmental causes as today's common attributions (194), which is not surprising considering;

1) The importance environmental issues have assumed since the 1960ies;
2) The large number of serious environmental accidents which have occurred during the last few decades, e.g. Three Miles Island and Seveso in 1976, Bhopal in 1984 and Chernobyl in 1986 (212-214);
3) The very special traits of real or perceived environmental threats. Among these traits are the uncertainty, invisibility and unpredictability of the threats, the fears for transgenerational effects, the conflicting positions within and between the expert communities, pressure groups and media, the possibility of social rejection and the frequent concomitant job insecurity (148,173,174).

In summary, it seems reasonable to suspect that the three above mentioned circumstances have increased the population's sensitivity and perception of common, non-specific symptoms and normal body signals (148,193,194,215), as well as the public's tendency to interpret them as being caused by environmental factors. Both the increased perception as well as the tendency to interpret in environmental terms, is frequently considered mediated by the extent and nature of the media coverage (148,174,206,216). They are also influenced by the interpretations made by doctors and lawyers, not the least if these professionals suggest alarming interpretations (148). In fact, it is the medical profession and associated institutions, which give legitimacy to old and new diseases by integrating them into the medical conceptual systems (209). Such a process of legitimisation of SBS was studied in Paper V. It was supposed that the legitimisation had a normative and prescriptive force contributing to maintain the SBS in the building. Thus, it seems as if positions taken by professionals and professional institutions are important for how symptoms are interpreted, as well as the determination of their final outcomes.

6 GENERAL CONCLUSIONS

The study was undertaken with the aim of contributing to the understanding of the development and maintenance of building-related, non-specific health problems. The following conclusions can be drawn:

- Sick building syndromes develop as a result of the interactions of factors pertaining to the bio-medical as well as to the psychosocial spheres. The relative importance of these factors and spheres vary from case to case, and may also vary with time in one and the same case. Thus, it seems as if there does not exist a SBS universe.
- The development and persistence of SBS were better understood if the cases were interpreted within the perspectives provided by integrated bio-psycho-social models. It was also suggested that the understanding of symptom development would be further enhanced if the bio-psycho-social models were inserted within a systems theory perspective.
- The above mentioned conclusions are of the utmost importance when considering remedial strategies, as well as for their execution. Buildings with emerging health problems should be dealt with from an integrated bio-psycho-social perspective. The need for this is underlined by the thesis' suggestion that neglect of the indicated holistic perspectives, more precisely of the psychosocial part, might lead to the persistence of SBS in spite of ambitious and supposedly correct measures carried out according to a bio-medical model.
- The definition of SBS was found to be complex and inadequate because of its vagueness and dualistic nature. These characteristics of the term's construction make its use in research inappropriate. Its ambiguous use in individual diagnoses in legal indemnity contexts confers an official status, suggesting a normative force, which, in turn, might contribute to symptom maintenance. For such reasons, its abandonment is proposed. However, it does not seem appropriate to replace it with terms such as "Indoor Air Syndrome" (36) or "Idiopathic Building Intolerance" (14). Such terms would suffer from the same problems as SBS. The propositions of Järvholm (35) and Spurgeon et al. (31) that SBS should be replaced with a descriptive approach of the encountered symptoms together with Baker's suggestion (37) that a building with health problems should be named "problem building" seem to be more adequate.

- There are severe research problems connected with the study of SBS and similar subjective syndromes which lack demonstrable biologic correlates, and when, at the same time, their environmental attribution is general, vague and non-specific (e.g. ”building”, ”multiple chemical”). The non-specificity of both outcome and exposure makes them unusually difficult to assess, leading to a number of serious biases. These problems make it particularly important to, in the study of such illnesses, use the widest possible variety of methods, as suggested for instance by Spurgeon et al. (153) and Crawford and Bolas (33). Not the least could different qualitative study designs be used, and it seems likely that the combined use of qualitative as well as of quantitative methodologies would strengthen the sum of their validity.

In summary, the overall conclusion is that the results of the thesis contribute to an enhanced understanding of the Sick Building Syndrome. It should, however, be evident that in this study area there do not exist final words or conclusions. Continued research will be needed to further promote the understanding of these health problems. This ought to be a very challenging research field with lots of room for the use and development of a large variety of methodological approaches.

7 SAMMANFATTNING PÅ SVENSKA

Sjuka Hus Syndromet (SBS) definieras vanligen som ett tillstånd av ohälsa bestående av varierande kombinationer av subjektiva symptom från dels slemhinnor i ögon, näsa, hals, svalg och övre luftvägar, dels huden, och dels andra symptom så som huvudvärk, trötthet, yrsel, illamående och koncentrationssvårigheter. Samtidigt är det i dessa fall i regel inte möjligt att genom medicinska undersökningar som röntgen, klinisk fysiologi, laboratorietester av blod och andra kroppsvätskor påvisa sjukliga förändringar.

Sjuka Hus Syndromet har varit vanligt i västvärlden sedan 1970-talet, och är numera ett ganska utbrett folkhälsoproblem. Dess uppkomst anses ha att göra med oljeembargot 1973, vilket ledde till ett behov av energisnåla, täta byggnader. Det anses också ha samband med att nya byggnadsmaterial mer allmänt togs i bruk på 70-talet, och att flera av dessa kan avge kemikalier till inomhusluften, i synnerhet vid samtidiga fuktskador.

Det har bedrivits en hel del forskning kring Sjuka Hus Syndromet, såväl i Sverige som internationellt. Denna har påvisat samband mellan förekomsten av syndromet och faktorer som byggnadens ålder, typ av ventilation, fuktskador, damm, arbetsförhållanden, rökvanor för att nämna några. Emellertid är den samlade erhållna vetenskapliga kunskapen ganska vag och allmän, och har därför svårt att ge vägledning till hur man kan förebygga Sjuka Hus Syndromet, och hur man kan hantera det i de fall där det uppkommit.

Det är mot denna bakgrund som avhandlingens främsta mål har varit att söka bidraga till förståelsen för hur Sjuka Hus Syndrom uppkommer och utvecklas. Tanken har varit att en ökad förståelse av detta skulle kunna ge vägledning till praktiskt agerande. Ett annat av avhandlingens mål har varit att undersöka konstruktionen av själva begreppet Sjuka Hus Syndromet, och dess definition. Detta mål var sammankopplat med avsikten att beröra och diskutera en del metodologiska forskningsproblem förbundna med studiet av subjektiva, ospecifika symptom som inte annat än undantagsvis kan påvisas med medicinsk teknik.

Avhandlingen har använt sig av en multi-fall studie-teknik. Fem olika byggnadsfall har utgjort basen för sex olika studier. Fyra av studierna har fokus på byggnaderna inklusive deras befolkningar, medan två av studierna har brännpunkten på några individer i relation till deras byggnader. Data insamlades på olika sätt. Tvärsnittsundersökningar med frågeformulär med och utan kontrollgrupper, liksom semi-strukturerade, öppna intervjuer användes. En mängd historiska dokument användes också som viktiga källor, t.ex. tekniska konsulters rapporter, protokoll från kommu-

nala nämnder och andra myndigheter, regionaltidningarnas arkiv, brevväxlingar, minnesanteckningar är exempel på dessa senare källor.

I varierande grad hade det i de olika fallen påvisats förekomst av fysiska skador byggnaden, oftast fuktskador, i en del fall i kombination med nedbrytning av spackel eller klister. I några fall hade också ventilationssystemen varit dåliga. Sannolikt hade symptom utvecklats till följd av dessa förhållanden, men avhandlingen fann även att det med dessa symtom i centrum utvecklades långdragna och komplicerade processer mellan olika grupper och enskilda såväl inom byggnaderna, som mellan byggnaderna och det omgivande samhället. Strukturella förhållanden så som ekonomiska aspekter och genusperspektiv tycktes ha ett inflytande över utvecklingen av dessa skeenden. Det föreföll som om de långdragna processerna tillsammans med inadekvat information och snåriga kommunikationsvägar resulterade i varierande grader av konflikttillstånd, och så småningom i tillstånd av minskad tillit i byggnaderna. Sammantaget verkade det som om Sjuka Hus Syndrom bäst kan förstås om de analyseras utifrån någon bio-psyko-social helhetsmodell. Det tycktes dessutom som att sådana helhetsperspektiv är av stor praktisk betydelse vid planering och genomförandet av åtgärder vid Sjuka Hus Syndrom.

Avhandlingen fann att själva termen SBS och dess definition är komplicerad och dubbeltydig, diffus och undanglidande, på ett sådant sätt att den ej är användbar som diagnos. Trots detta konstaterades att den i praxis, bl.a. genom myndigheters tillämpning, har en officiell, legal status, och det förmodades att detta kunde ge termen en olycklig normativ effekt.

Slutligen fann avhandlingen att de metodologiska forskningsproblemen vid studiet av miljörelaterade, ospecifika syndrom som SBS är mycket stora. Problemen var av sådan art att det föreföll som om i dessa sammanhang kvalitativa undersökningsmetoder kunde vara väl så lämpade som kvantitativa.

Avhandlingens allmänna slutsatser var

- Sjuka Hus Syndrom utvecklas till följd av flera samverkande faktorer. Faktorernas enskilda betydelse varierar från fall till fall, och från tid till tid i ett och samma fall. Det tycks alltså inte finns något universellt giltigt Sjuka Hus Syndrom.
- Utvecklingen av Sjuka Hus Syndrom förstås bäst om analytiska helhetsperspektiv används. Fall bör utredas och åtgärdas genom analys och identifiering av möjliga predisponerande, utlösande och vidmakthållande faktorer inom såväl de biologisk/kemisk/fysikaliska som psykologiska och sociala sfärerna.
- Begreppet SBS bör överges.

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