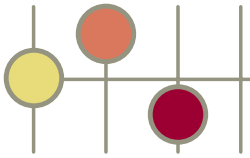

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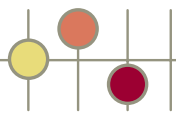
Scoping Review of Sabotage and/or Tampering in the NHS



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REPORT 25

Scoping Review of Sabotage and/or Tampering in the NHS

Commissioned by the National Patient Safety Agency (NPSA)

Produced by the Centre for Reviews & Dissemination (CRD), University of York

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Executive summary

A scoping review on sabotage or tampering (within the NHS) with intent to injure was commissioned by the National Patient Safety Agency (NPSA). This followed reports of blocked anaesthetic tubing during surgical procedures, which could have been the result of deliberate sabotage.

Objectives

To undertake a scoping review of the literature relating to:

1. sabotage or tampering, with intent to injure, of equipment or medical products by staff, patients, carers or anyone else with access.
2. solutions that help to minimise the risk of sabotage or tampering.

Literature from fields other than healthcare were considered relevant. The aim of the scoping review was to map the literature relating to sabotage or tampering.

Methods

As far as possible the scoping review was undertaken in accordance with CRD's Guidelines for Undertaking Systematic Reviews. Different types of evidence were considered to reflect the existing literature investigating sabotage or tampering. Weekly contact was maintained between CRD and the NPSA.

A range of databases in several subject areas was searched to identify documents dealing with sabotage or tampering. In addition the websites of key organisations (such as the Federal Aviation Authority) were searched for relevant publications and a general web search was undertaken.

Initial investigation of the search results identified a number of categories into which records could be sorted. Titles and (where available) abstracts were categorised by one or two reviewers. The results of the initial categorisation exercise were discussed with the NPSA before decisions were taken about which categories full papers should be retrieved for.

Data were extracted by one reviewer and random checks were made for accuracy. Data were summarised by category, and hierarchically according to relevance to the NPSA.

Findings and implications for the NHS

A total of 6846 records were identified through the electronic searches, of which one hundred and eighty (180) articles were included. Most were published in the USA. The articles covered various aspects of sabotage or tampering, ranging from establishing the extent of the problem through factors

that may cause it, to possible interventions for its prevention and detection. The settings in which sabotage or tampering had been investigated also varied and included clinical practice, the food industry and nuclear sites.

Tampering with equipment or drugs or clinical practice

There may be implications for the NHS with regard to patient safety in relation to the tamper-evident tape described in one study, which could be used to seal packs of equipment or drugs that need to be protected from tampering. Similarly, a series of uncontrolled experiments to evaluate the utility of various forms of tamper evident packaging may offer possibilities for the NHS. Two case-control studies are also likely to be of interest, as they identified the theft of narcotics, probably by hospital staff, as a potential danger to patients. In both of these studies adulterants were substituted and the recommendations that came from the studies were that mechanisms to deal with theft of patients' medication should be in place, such as hair testing. Other potential implications for the NHS include the findings from one study where a patient had died and it was suspected that this was due to a malicious act. The study was based on a series of laboratory tests and focussed on the accurate detection of digoxin intoxication from post-mortem examination, by measurement of digoxin-like immunoreactive substances (DLIS).

Tampering with patient records

The potential for watermarking patient records (either paper or electronic) to prevent or detect tampering was highlighted in one study.

Organisational factors associated with sabotage or tampering

The available research literature suggests that frustration and feelings of inequity in the workplace (perceived or otherwise) may be one possible cause of sabotage. Management intervention to handle worker conflict, reduce tension causing situations and promote security awareness was advocated.

Tampering with food/water systems

The findings from one study, although not from clinical practice, may be relevant to the NHS. A risk assessment was made of the potential threat of tampering with water systems, which could perhaps be applied in NHS settings to identify areas of vulnerability within hospitals. The other studies did not have direct implications for the NHS but perhaps some of the techniques they described could be applied if tampering with hospital food is suspected.

Sabotage at nuclear sites

None of the articles appeared to be of direct relevance to the NHS, however, many of the modelling techniques described could be adapted to develop methods for investigating insider threats of sabotage in NHS facilities.

Conclusions

Overall, the research literature relevant to sabotage or tampering in a health service context is very limited and offers few direct implications for the NHS. The issues considered to be of most relevance, and with potential for further action are outlined below.

- Consideration of systems and procedures for the accurate and thorough reporting of sabotage or tampering when it is suspected.
- Consideration of the use of alarms or packaging to prevent tampering with equipment or drugs.
- Consideration of the use of packaging to detect tampering with equipment or drugs.

Suggestions for a future research agenda include investigation of the prevalence of sabotage or tampering across the NHS; the factors that might lead to sabotage or tampering together with the evaluation of interventions to prevent, detect or reduce sabotage or tampering.

Introduction

Background

A scoping review on sabotage or tampering (within the NHS) with intent to injure was commissioned by the National Patient Safety Agency (NPSA). This followed reports of blocked anaesthetic tubing during surgical procedures in hospitals across the UK, which could have resulted from deliberate acts of sabotage.

Objectives

To undertake a scoping review of relevant literature relating to:

1. sabotage or tampering, with intent to injure, of equipment or medical products by staff, patients, carers, or anyone else with access to healthcare equipment.

2. solutions that help to minimise the risk of sabotage or tampering.

Literature from fields other than healthcare were considered relevant. The aim of the scoping review was to map the literature relating to sabotage and tampering.

Methods

As far as possible, the scoping review was undertaken in accordance with CRD's Guidelines for Undertaking Systematic Reviews (http://www.york.ac.uk/inst/crd/report4.htm).

Review boundaries

Sabotage or tampering in a health service context was of particular interest to address objective 1. All potentially relevant evidence was eligible to address objective 2, including experience from non-health service settings such as the food industry and transport services. Different types of evidence (e.g. research, patents advertisements, instruction manuals, company guidelines etc.) were initially considered, to reflect the existing literature about sabotage or tampering. Weekly contact was maintained between CRD and the NPSA to ensure that the boundaries described were appropriate.

Search strategy

A range of databases in several subject areas was searched to identify documents dealing with sabotage or tampering (see Table 1). Given that this was a scoping review and that it was difficult to compose a very specific search, the search was broad and identified a large number of irrelevant records. The term sabotage has been used in many contexts that are unrelated to the interest of this review, but it was difficult to exclude possibly irrelevant records at the search stage.

The search strategies designed and used are presented in Appendix A.

In addition, the web sites of key organisations such as the Federal Aviation Authority, the Civil Aviation Authority and the International Atomic Energy Authority were searched for relevant publications. A general web search was also undertaken.

Review process

The citations identified from the searches were imported into the reference manager Endnote, which allows for easy de-duplication of records. An initial investigation of the results of the searches identified a number of categories into which the records could be sorted. The first 2414 titles and (where available) abstracts were categorised by two reviewers independently and differences were resolved by discussion. The two reviewers held detailed discussions of the first 400 of these records before proceeding to categorise the rest. The agreement between the two reviewers about the first 400 records (prior to the discussion) was 53%. When the other 2014 records had been categorised independently by the two reviewers, random checks were made of their decisions and a high degree of agreement (94%) was seen. Due to time constraints, it was then decided to use only one reviewer to categorise the remaining 4832 records. Where it was not possible to categorise the record from the

title and abstract, the full article was requested. Where only titles were available and the article looked potentially relevant, the abstract was retrieved before the full article was requested.

Table 1: Databases searched

MEDLINE	(biomedical)
EMBASE	(biomedical)
PsycINFO	(psychological literature)
CINAHL	(nursing)
Cochrane Library	(biomedical)
Science Citation Index	(general science including energy, transport, food, biomedical)
Foodline	(food industry)
Foods Adlibra	(food industry)
Food Science and Technology Abstracts	(food industry)
TRIS	(transport)
Energy SciTech	(energy)
PreMEDLINE	(biomedical)
National Research Register	(health and medical)
SIGLE	(report literature, grey literature)
HMIC	(health policy and management)
Inspec	(science and engineering)
NTIS	(technical reports in sciences)
EI Compendex	(engineering)
Graylit	(web site for US technical reports)
Harvard Business Review	(management)
ABI/Inform	(management)
Management Contents	(management)
Management and Marketing Abstracts	(management)
Business A.R.T.S.	(management and business)

The results of this initial categorisation exercise were discussed with the NPSA before decisions were taken about the categories to retrieve full papers for.

The approach used for the process of categorising the records and studies retrieved was loosely based on thematic analysis. Thematic analysis involves the identification of recurrent themes in the literature (often involving an initial tabulation of papers which will contribute data on each theme) together with a summary of the different studies under thematic headings. The thematic approach

undertaken in this review was data driven, as it was guided by the themes identified in the literature itself. This approach allows clear identification of prominent themes, together with a structured approach to dealing with the literature under each theme.

The categories were:

Type of article: Research (RES)
Patent, or description or advertisement (PAT)
Other (OTH)

Table 2: List of topics

TPP	Tamper-proof packaging
TEP	Tamper-evident packaging
TPP/TEP	Both tamper-proof and tamper-evident packaging
NUT	Nuclear materials – sabotage during transportation
NUC	Nuclear materials – on-site sabotage
RWY	Railway sabotage
CAR	Automobile sabotage
AIR-B	Aircraft security - bombs
AIR-G	Aircraft security – ground staff
REC	Tampering with medical records
EQI	Tampering with medical equipment
DRU	Tampering with drugs
ORG	Organisational (reasons why sabotage may occur and predictors of sabotage; documenting sabotage of inter-professional relationships)
PSY	Psychotherapy articles about self-sabotage (relationships, success etc)
FAL	'False drops' e.g. tamping in civil engineering; 'sabotage' by policy; genetically modified food; DNA tests; forensics; microbial ecology; domestic violence; encryption of computer records for transmission
EDU	Teaching (of staff/ students)/ how to prevent sabotage occurring
EMG	Police, fire, ambulance malicious false calls
TES	Tampering with clinical laboratory testing results, not food (urine, e.g.), including cases of Munchausen's syndrome by proxy
FOD	Tampering with food (adulteration)
TER	Tampering by terrorists
PRA	Tampering with clinical practice (e.g. Beverley Allitt case, malicious administration of insulin)
SEL	Deliberate or accidental self-harm by tampering with equipment or medication or medical care
RES	Tampering with research (e.g. trying to break the code in a clinical trial)
POW	Tampering with power supplies
BUS	Tampering with buses
SHP	Tampering with ships
BKG	Definitions, background reading
UNK	Unknown – due to lack of information – abstract and/or full paper ordered.

After consultation with the NPSA, full papers were retrieved for **research** studies only, in the following selected topic categories:

- tampering with equipment
- tampering with drugs
- tampering with clinical practice
- tampering with laboratory tests
- tampering with records
- organisational factors
- tamper-proof and/ or tamper-evident packaging
- tampering with food
- tampering leading to self-harm
- educational interventions
- sabotage of emergency services
- sabotage at nuclear sites
- sabotage of nuclear transport
- tampering with research
- psychological (self) sabotage
- sabotage of railways

Relevant data from each study were extracted systematically by one reviewer into tables (Appendix B) and each of the categories are discussed narratively. Random checks by a second reviewer were made of the data extraction tables.

Results summary

A total of 6846 records (titles and in some cases abstracts) were identified via the electronic searches. In Table 3 below, categories are displayed in order of the number of hits, highest first. The third column (research) is a subset of the second column (number of records).

The full papers were ordered for a total of 200 records. Thirteen papers were ordered but had not arrived at the time of writing this report. Nine of these thirteen related to nuclear site sabotage, one to sabotage of nuclear transportation, two covered psychological factors, and one covered tampering with equipment. Details of these records are listed in Appendix C.

Seven of the articles ordered were delivered as microfiche. Each one was considered relevant, but we were unable to extract any data from these reports in the time available. Three of these covered nuclear site sabotage (one of these also contained information about tampering with automobiles), two covered sabotage of nuclear transport, one covered sabotage on the railways and one covered tamper evident packaging. Details of these seven records are listed in Appendix D.

Table 3: No of records in each category

Category	Total records	Research
FAL	2646	31
TPP/TEP	1861	4
FOD	287	17
NUC	753	87
NUT	65	11
PSY	68	7
ORG	95	19
DRU	130	17
CAR	88	24
TER	49	2
TES	52	20
EQI	50	9
AIR-G	43	0
SEC	67	3
RWY	22	1
POW	78	3
AIR-B	27	3
REC	46	3
PRA	16	1
SEL	11	1
EDU	8	1
WEA	9	2
EMG	7	1
SHP	7	0
BUS	1	0

A total of one hundred and eighty (180) articles were included in the review and relevant data has been extracted and is presented in tables in Appendix B.

The majority (135) of articles were published in the USA. Eleven were from the UK, three were from India, three from Spain, three from Taiwan and one or two each from Canada, France, Germany, Slovenia, Sweden, Australia, Czech Republic, Ireland, Israel, Luxembourg, Singapore, South Africa, and Switzerland. The place of publication was unclear in seven articles.

Table 4: Countries represented by articles included in review – overall

Country	Number of articles
USA	135
UK	11
Canada	2
France	2
Germany	2
Spain	3
Slovenia	1
Sweden	1
Australia	2
Czech Republic	1
India	3
Ireland	1
Israel	1
Luxembourg	1
Singapore	1
South Africa	1
Switzerland	2
Taiwan	3
Not known	7

A fairly constant rate of publication seems to have been maintained during the years from 1981 to the present day, with 24-39 included articles being published in each five year time period. Thirty-three articles were published before 1981.

Fifty-three articles, mostly from the nuclear industry, focussed on vulnerability, safety or risk assessment of facilities. Forty-seven articles focussed on detection, usually of adulteration of food, drugs or samples for laboratory tests. Thirty-seven studies reported interventions to prevent or identify sabotage or tampering. Twenty-eight studies focussed on identifying the extent of the sabotage or tampering problem. Five articles, mainly from the nuclear industry, focussed on emergency planning and ten focussed on factors that may cause or foster the development of sabotage or tampering.

Table 5: Estimated date work was carried out for articles included in review - overall

Estimated date work carried out	1980 or earlier	1981-5	1986-1990	1991-1995	1996-2000	2001 or later
Number of articles	33	24	25	39	33	26

Table 6: Numbers of articles and their focus – overall

Focus	Number of articles
Detection	47
Intervention	37
Safety assessment	30
Vulnerability or Risk assessment	23
Emergency planning	5
Causation	10
Prevalence	28

Table 7: Approaches used across the articles – overall

Method	Number of articles
Equipment or process evaluation	11
Discussion paper	13
Case-control study	2
Pre-post test study (uncontrolled)	2
Theoretical model	59
Consensus guidelines	2
Literature review (non-systematic)	11
Systematic review	1
Controlled study	7
Cost analysis	3
Database analysis	2
Descriptive	4
Interviews	3
Laboratory tests	39
Observational study	3
Questionnaire	2
Retrospective record review	3
Report of speech	1
Report of workshop	1
Survey	8
Case series	1
Scale development	1
Content analysis	1

The designs of the included studies (or articles) varied widely. Some articles (59) were theoretical in nature and presented or discussed theoretical models of vulnerability pathways or security measures. This reflected the large number of articles that focussed on safety, risk or vulnerability assessment, or emergency planning. Other articles (39) took the form of laboratory tests, with a focus on the detection of adulteration of products or samples.

A narrative synthesis is presented of the research articles identified within each topic category, including their aims and objectives and any possible implications for the NHS. Topic categories are presented in a hierarchical order, according to the relevance and interest we think each category may have to the NPSA. No research articles were obtained which related to sabotage of railways.

Tampering with equipment (EQI)

Eight articles fitted into the 'EQI' category.[1-8] Six studies focussed on the identification of the extent of the problem (equipment tampering): two of these were prospective observational studies (one of intravenous patient-controlled analgesia[2] and one of home ventilators[6]) and three were retrospective record reviews (one of laparoscopic management of malignant ovarian cysts,[3] two of patient controlled analgesia, one in children[4] and one in people with sickle-cell haemoglobinopathies[5]). The remaining study was an evaluation of different patient-controlled analgesic pumps.[1]

Two studies in this category focused on interventions to prevent, or offered potential solutions for the prevention of, tampering with equipment. One focussed on vulnerability assessment of nuclear equipment using a theoretical computer model[7] and the other focussed on an intervention (the Alcopatch, a tamper-evident transdermal dosimeter for the measurement of alcohol consumption) using an uncontrolled post-group evaluation design.[8]

Seven of the eight studies were carried out in the USA[1, 2, 4-8] and the country of origin of the eighth study[3] was unclear. Five of the eight studies were carried out after 1995.[1, 3, 4, 6, 8]

Table 8: Summary table methods (EQI)

Methods	Equipment evaluation	Prospective observational study	Retrospective record review	Theoretical model	Uncontrolled study
Number of studies	1	2	3	1	1

Table 9: Summary table place of study (EQI)

Country	USA	Unclear
Number of studies	7	1

Table 10: Summary table date of publication (EQI)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 and later
Number of studies	0	0	1	5	1	1

Implications

A number of potential implications were evident from this set of studies. Of the four non-intervention studies of patient-controlled analgesia, two additionally addressed the issue of how to make the devices tamper-proof and both speculated that, as almost all devices have an alarm which sounds when the device is tampered with, other safeguards do not seem necessary.[2, 5] One study noted that the use of such devices requires adequate training for physicians and nurses, and should only be used where constant physician and nursing care with an active quality assurance programme is available.[2] The other study noted that conventional intravenous infusion systems are not locked and could therefore undergo unauthorised changes.[5] The study of patient-controlled analgesia in children concluded that the method was safe and effective over a period of several days or weeks.[4] The equipment evaluation study seemed to be using susceptibility to tampering as one of its criteria for evaluating the PCA pumps, but did not report any conclusions or implications.[1] The study of home ventilator failure reported that improper equipment care, damage or tampering by caregivers was responsible for 13% of reported ventilator failures and 30% of failures were due to functional equipment being used improperly by caregivers.[6] In this study, none of the reported damage or tampering appeared to be malicious and most was dealt with by providing ongoing education.[6] The authors proposed improved patient and caregiver education and support to reduce reports of home ventilator failure.[6] The study of laparoscopic management of malignant ovarian cysts did not have any implications relevant to deliberate sabotage or tampering.[4]

The recommendations arising from the two studies which presented interventions or solutions for tampering with equipment were that use of the structured assessment approach (SAA) computer program may increase the thoroughness of security measures to prevent sabotage of equipment;[7] and the Alcopatch may be useful as a means of monitoring alcohol consumption due to the tamper-evident tape with which it is attached, in people whose self-reports are potentially unreliable.[8]

Implications for the NHS

There may be implications for the NHS where patient-controlled analgesic devices are used in inpatient settings. Training for physicians, and nurses together with constant care and an active quality assurance programme is recommended. When a ventilator device is used at home, ongoing education and support for patients and caregivers is recommended. The alarm systems that are reported to be attached to most patient-controlled analgesic devices, are likely to prevent tampering. The implications for the NHS from the study of tamper-evident tape arise from its original purpose, which was to detect tampering in the financial community. Tamper evident tape was used to detect tampering with sealed bags containing valuables. Tamper evident tape could be used in the NHS to detect tampering with sealed bags containing equipment. The vulnerability assessment study may also have implications for the NHS if the computer model used could be modified to produce a structured assessment of the thoroughness of security measures to prevent sabotage of equipment in an NHS setting.

Table 11: Summary table of included studies (EQI)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Anonymous, 2001[1]	USA	Intervention	Evaluation of equipment	To evaluate nine patient-controlled analgesic (PCA) pumps from six suppliers.	None stated.
Ashburn, 1994[2]	USA	Prevalence (extent of problem)	Prospective observational study	To identify the underlying causes of respiratory-related critical events associated with intravenous patient-controlled analgesia (IV PCA).	It was determined that the design of the PCA device contributed to the misprogramming errors and the device was removed from service. Changes in the training of physicians and nurses were instituted to avoid recurrence of other errors identified. The incidence of serious respiratory-related critical events was 0.1%. IV PCA therapy has the risk of potentially serious complications and requires constant physician and nursing care with an active quality assurance programme. In this study, the patient who tampered with the device was unsuccessful in accessing the opioid. Almost all PCA devices have an alarm which sounds when the device is tampered with. The authors conclude that other safeguards do not seem necessary in their clinical practice.
Blanc, 1995[3]	Unclear	Prevalence (extent of problem)	Survey: Retrospective record review	To determine the incidence of laparoscopic management of malignant ovarian cysts.	To prevent the risk of metastasis, thorough pre-operative and post-operative evaluation is mandatory.
Dunbar, 1995[4]	USA	Prevalence (extent of problem)	Retrospective record review	To present a retrospective review of the use of patient controlled analgesia (PCA) in 39 preteen children and to describe the methodology for PCA used in this age group.	The authors conclude that opioid PCA, with or without continuous infusion (CI), over several days or weeks is safe and effective for preteen children suffering bone marrow transplantation (BMT)-related pain.
Patenaude, 1986[7]	USA	Vulnerability assessment	Theoretical computer model	To describe the structured assessment approach (SAA) used to assess the vulnerability of safeguard systems to insiders in a staged manner.	The SAA programme allows for a computer-aided step-by-step analysis of vulnerabilities for physical security and material accounting systems. At each step, the programme aids the assessor in keeping the facility description logically consistent and in revealing vulnerabilities that may not have been apparent using informal analysis. The programme provides the framework for building up a detailed description of the facility in a way that can significantly increase the thoroughness of safeguards evaluation and documentation.
Phillips, 1995[8]	USA	Intervention	One group post-evaluation	To evaluate the performance of the Alcopatch, a tamper-evident transdermal dosimeter for the	The Alcopatch may be most useful in the future as a means of monitoring alcohol consumption by people whose self-reports are potentially unreliable.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
				measurement of alcohol consumption.	Other implications: tamper-evident tape as described here may have useful applications. It was originally developed in response to a need in the financial community to detect tampering with sealed bags containing valuables.
Shapiro, 1993[5]	USA	Prevalence (extent of problem)	Retrospective review of case records	To delineate dose ranges, utilisation patterns, and frequency and types of problems encountered by patients with sickle-cell haemoglobinopathies who used patient-controlled analgesia (PCA) for the management of vasoocclusive pain.	Patient satisfaction with PCA probably reflects interactions among the psychosocial impact of chronic illness and chronic pain, individual psychological and temperamental factors, environmental contingencies, and the expectations and beliefs of the family and the health-care professionals. Most PCA devices are resistant to tampering; the supply of opioid is locked, and using the machine without the proper code sets off an alarm. Conventional intravenous infusion systems are not locked and are more available to unauthorised changes. Tampering does not represent a problem specific to PCA. All such behaviour must be taken seriously. The patient received intensive individual and family psychotherapy after the tampering.
Srinivasen, 1998[6]	USA	Prevalence (extent of problem)	Prospective monitoring study	To study frequency of home ventilator failure, apparent causes for the failure or malfunction and adverse consequences following the failure.	Improper equipment care, damage or tampering by caregivers was responsible for 13% of reported ventilator failures and 30% of failures were due to functional equipment being used incorrectly by caregivers. Improved patient and caregiver education and support may reduce reports of home ventilator failure. In this study, none of the reported damage or tampering by caregivers appeared to be malicious, and most was dealt with by providing ongoing education.

Tampering with drugs (DRU)

Seventeen articles were identified which fitted into the category 'DRU'.[9-25] Eight studies were carried out in the USA,[9,12,13,17,19,21-23] three in the UK,[10,11,18] one in Taiwan,[14] one in Spain[15] one in Canada,[20] one in Singapore[24] and one in India.[16] In one study the country of origin was unclear.[25] Nine of the seventeen studies were published after 1995.[10,11,13-15,17,18,21,26] The main objective in six studies was to identify the extent of the drug tampering problem: two of these focused on the adulteration of Chinese herbal medicines[10,11] (one was a systematic review[10] and one a non-systematic literature review[11]), one was a descriptive study of the demographics of an epidemic of poisoning caused by heroin adulterated with scopolamine,[13] two were laboratory studies, one of which focused on adulterants in heroin from southern Spain,[15] and one on arsenic levels in Indian tobacco.[16] The sixth of the prevalence studies was a non-systematic literature review of publications that advocated the use of product tampering and other poisoning methods for revenge, murder or other criminal purposes.[9]

Eleven studies focussed on the detection of drug tampering.[12,14,17-25] Two of these were case-control studies from the USA: one was undertaken to determine the cause of unexplained postoperative respiratory distress syndrome (ARDS) in adults[12] and one was undertaken to investigate the source of an outbreak of hospital acquired Serratia marcescens bacteraemia.[17] The third study was laboratory based and investigated suspected adulterated Chinese medicines.[14] Four more studies also used laboratory tests to detect drug tampering,[18,21,22,24] and two evaluated refractometers.[19,20] Two other studies focused on interventions to detect or prevent drug tampering or offered solutions. One was a cost-benefit analysis of methods for preparing intravenous infusions,[23] and one was a cost and effectiveness study for the preparation of respiratory therapy solutions.[25]

Table 12: Summary table methods (DRU)

Methods	Systematic review	Literature review (non-systematic)	Case-control study	Laboratory tests: uncontrolled or unclear	Laboratory tests: controlled	Equipment/ procedure evaluation	Cost-benefit analysis	Descriptive study
Number of studies	1	2	2	7	1	2	1	1

Table 13: Summary table place of study (DRU)

Country	USA	UK	Taiwan	Spain	India	Canada	Singapore	Unclear
Number of studies	8	3	1	1	1	1	1	1

Table 14: Summary table date of publication (DRU)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 and later
Number of studies	1	1	1	4	6	4

Implications

The systematic and non-systematic reviews of Chinese herbal medicines concluded that adulteration of these medicines with synthetic drugs is a potentially serious problem which needs to be addressed by adequate regulatory measures.[10,11] The author of the non-systematic review of publications which advocated product tampering suggested that retailers reconsider the sale of such publications, that food and drug manufacturers test the effects of the recommended contaminants on their products and that investigators be alert to the existence of these manuals and mail-order supplies of poison.[9]

One of the heroin studies (from Spain) concluded that the potential toxicity of adulterant metals studied at the concentrations found was low and the susceptibility of each individual, such as the effect of cumulative doses, should be considered.[15] The other heroin study concluded that poison centres are essential for identification of street drug adulteration trends, and are the primary source of information on diagnosis and treatment. This article appeared to be primarily a promotion of poison centres.[13]

The results of the study on adulteration of Indian tobacco suggested that the tobacco was adulterated with arsenic, but no implications were presented.[16] The Taiwanese study on adulteration of Chinese medicines recommended a monitoring programme run by health authorities to identify adulterated traditional medicines, public education on the hazards of adulteration and legislative requirements on adequate labelling of dispensed medicines.[14]

The two case-control studies both found that theft of narcotics and their replacement with another substance, probably by hospital staff, was responsible for the outbreaks of illness.[12,17] In one of these studies, the adulterant was not identified but measures to prevent tampering with infusion devices terminated the epidemic. The authors suggested that measures to inhibit theft and tampering should be applied to fentanyl infusions in critical care, and that unexplained physiological deterioration in a patient receiving fentanyl infusion should prompt discontinuation of the fentanyl and investigation into the possibility of tampering with the infusate.[12] The authors of the other case control study suggest that hair testing may be useful to detect the culprit when theft is suspected and that adequate mechanisms should be put in place to deal with theft of patients' medications and any resulting adverse events.[17]

One study evaluating refractometers concluded that hand-held refractometers appeared to be useful tools for pharmacists in monitoring the integrity of drug solutions.[19] However a later study concluded that refractometry is an unreliable screening method to detect tampering with opioid solutions.[20] Two

studies advocated the use of high-pressure liquid chromatography (HPLC) for the analysis of goldenseal products[21] and Tussionex formulations,[22] and a third found 'chromatography' to be useful for screening Chinese medicines.[24] Two studies examined the costs and benefits of preparing drug solutions in different ways. In one, cost savings were made by preparing selected continuous intravenous infusions in a standard concentration as opposed to a varied concentration. Additional advantages included recycling, decreased preparation time, ease of dosage calculations and increased accuracy.[23] In the second study, a programme of preparing respiratory therapy solutions and medications in a tamper-proof disposable unit-of-use package was found to cost ten cents more than a non-tamper-proof system and to reduce medication errors.[25] However, this study was carried out nearly thirty years ago, in 1975.

A study investigating the effects of adulterants on an enzyme immunoassay (EIA) for LSD concluded that certain products can significantly alter the results of an EIA.[18]

Implications for the NHS

There may be implications for the NHS with regard to patient safety, particularly from the two case-control studies[12, 17] that identified the theft of narcotics by hospital staff as a potential danger to patients. Measures to prevent tampering with fentanyl infusion devices appeared to be effective in one study,[12] along with prompt investigation of possible tampering in sudden physiological deterioration in patients receiving fentanyl infusions. The other case-control study[17] also suggested that adequate mechanisms to prevent theft and resulting adverse events should be in place.

There are possible implications for the NHS arising from the two studies of preparation of drug solutions,[23,25] but these may contradict each other. The older study[25] found that preparing drug solutions centrally in a disposable, tamper-proof, unit-of-use package, rather than having staff prepare solutions on the ward, reduced medication errors. The later study[23] found that preparing standard, as opposed to varied, concentrations on intravenous solutions led to increased accuracy.

Table 15: Summary table included studies (DRU)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Cassells, 1998[18]	UK	Detection	Laboratory tests	To investigate the effects of 15 chemicals and household agents on an enzyme immunoassay (EIA) for LSD.	The presence of certain compounds or products can significantly alter the results of an enzyme immunoassay, in this case an EIA for LSD.
Cheung, 1991[19]	USA	Detection	Equipment evaluation	To address the questions: 1) what are the reproducibility and reliability of refractive index measurements of drug solutions?; 2) Are they dependent on the refractometers used?; 3) What are the within-day and between-day variabilities of these measurements?; 4) What commonly used solutions of controlled substances can be screened by this approach?; and 5) Are there ways by which such refractometric screening can be subverted?	Despite some limitations (described fully in the paper), hand-held refractometers appear to be useful tools for pharmacists in monitoring the integrity of drug solutions. Little training is required, and the amount of sample required per test is only about 100 microL. The screening procedure is rapid, simple, reproducible, and inexpensive and is applicable to a wide array of drug solutions.
Dietz, 1988[9]	USA	Prevalence (extent of problem)	Literature review (non-systematic)	To review publications that advocate the use of product tampering and other poisoning methods as techniques for exacting revenge against individuals and corporations, as methods of committing murder, and for other criminal purposes. Several of the particular techniques recommended in these publications subsequently have been used in criminal tampering incidents.	The author suggests that food and drug retailers consider the wisdom of selling magazines that advertise the availability of revenge and murder manuals advocating product tampering and poisoning, that food and drug manufacturers test the effects on their products of the contaminants that are being recommended and that investigators be alert to the existence of such manuals and mail-order supplies of poisons.
Eagle, 1994[20]	Canada	Intervention	Laboratory tests	To assess the value of refractometry in identifying the contents of a variety of opioid-containing solutions.	Refractometry is an unreliable screening method to detect tampering with opioid solutions.
Ernst, 2002[10]	UK	Prevalence (extent of problem)	Systematic review	To summarise data regarding adulterations of Chinese herbal medicines with conventional drugs.	Adulteration of Chinese herbal medicines with synthetic drugs is a potentially serious problem which needs to be addressed by adequate regulatory measures.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Ernst, 2002[11]	UK	Prevalence (extent of problem)	Literature review (non-systematic)	To review evidence suggesting that some Asian herbal medicines contain toxic heavy metals or undeclared prescription drugs.	The consumer should be informed that 'natural' does not necessarily mean 'free from risk' and that adverse effects as a result of Asian herbal medicines are an undeniable reality. Patients and physicians should be encouraged to talk about the use of Asian herbal medicines and other complementary or alternative treatments and the possibility of interactions of herbal medicines with prescribed drugs. Regulators should consider measures to control this sector of healthcare more effectively.
Goetz, 1994[12]	USA	Detection	Case control study	To determine the cause of unexplained postoperative adult respiratory distress syndrome (ARDS).	The authors suspect that one or more individuals removed fentanyl infusate from the bottle & replaced this volume with another substance. Investigations failed to identify an adulterant, however measures to prevent tampering with infusion devices successfully terminated the epidemic. Critical care personnel using fentanyl infusions for analgesia should consider measures to inhibit theft and tampering. Unexplained physiological deterioration in a patient receiving fentanyl infusion should prompt discontinuation of the fentanyl and investigation into the possibility of tampering with the infusate.
Govindan, 2000[21]	USA	Detection	Laboratory tests	To investigate a convenient method for the determination of the quality and possible adulteration of goldenseal (a herbal supplement).	These results indicate that TLC is a viable method for the qualitative analysis of goldenseal products but high-pressure liquid chromatography (HPLC) remains the best available method for the quantitative estimation of the active alkaloid content in these products.
Hadzija, 1996[22]	USA	Detection	Laboratory tests: controlled study using samples	To apply high-performance liquid chromatography (HPLC) for the separation and quantitation of hydrocodone (HCD) for application to the analysis of the drug in the sustained-release suspension of Tussionex Pennkinetic.	The proposed analytical method is specific, accurate and rapid, and is suitable for routine analysis of Tussionex formulations.
Hamilton, 2000[13]	USA	Prevalence (extent of problem)	Descriptive study	A report of the demographics and clinical characteristics of an epidemic of poisoning caused by heroin adulterated with scopolamine.	Adulteration of street drugs can lead to toxic epidemics. Poison centres are essential for identification of these trends and are the primary source of information on diagnosis and treatment. Although the report gives detail on this epidemic of poisoning, the aim of the study appears to be the promotion of the need for poison centres.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Huang, 1997[14]	Taiwan	Detection	Laboratory testing	To screen samples of traditional Chinese medicines in Taiwan, suspected of adulteration, that were used by the patients in several major hospitals. It was purported to serve as a basic model of incorporating hospitals into a safety-monitoring system for traditional Chinese medicines.	The authors recommend that health authorities in Taiwan continue to monitor and to provide screening services to the public for traditional medicine. This monitoring programme provides a mechanism to identify adulterated traditional medicines. Public education on health hazards of such adulteration should be advocated. In addition, legislative requirements on adequate labeling of dispensed medicines, showing particularly the name of the product or its ingredients, is essential in enforcing prohibition of such hazardous practices. As for the countries that have not established adequate regulations covering the distribution of traditional Chinese medicines, the appropriate health authorities should be made aware of the potential hazards in such illegal adulterations to the health of their public.
Infante, 1999[15]	Spain	Prevalence (extent of problem)	Laboratory testing	To analyse illicit heroin from Andalusia (southern Spain) in order to quantify its contents in some metals with a view to examining a new aspect of the conditions under which it is taken by addicts.	The results show that, in some cases, the presence of a given metal in heroin can be related to the presence or absence of another metal. Based on the results, it was concluded that the potential toxicity of the metals studied at the concentrations found is relatively low. Only cadmium, and to a lesser extent, zinc and copper and always at the highest concentrations found, might add to the intrinsic toxic effect of the drug. In any case, the susceptibility of each individual must always be considered, such as the effect of cumulative doses due to the frequency of the drug's administration.
Jenkins, 1985[23]	USA	Intervention	Cost-benefit analysis	To examine the significance of cost savings by preparing selected continuous IV infusions in a standard concentration as opposed to a varied concentration.	Additional advantages include recycling, decreased preparation time, ease of dosage calculations and adjustments and increased accuracy. No further mention in the results of tamper-proof seals.
Liu, 2001[24]	Singapore	Detection	Laboratory testing	To develop an analytical technique to rapidly screen for undeclared toxic and therapeutic substances in Chinese proprietary medicines (CPM).	The screening and identification of undeclared therapeutic substances in CPM is a very challenging task. The chromatographic methods in this study have shown to be selective and reproducible. Of the 41 samples, only one was found to contain undeclared codeine. Greater awareness of and control over the safety and quality of CPM are necessary.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Narang, 1995[16]	India	Prevalence (extent of problem)	Laboratory tests	Objective appears to be to determine arsenic levels in Indian tobacco.	Suggests adulteration of tobacco with arsenic.
Ostrowsky, 2002[17]	USA	Detection	Case-control study	From June 30, 1998 to March 21, 1999 several patients in the surgical intensive care unit of a hospital acquired Serratia marcescens bacteraemia. The authors investigated this outbreak to define the extent of the problem, identify the source and risk factors and implement control measures.	Theft of narcotics and the potential for resulting complications in patients remains a problem in health care settings. Hair testing may be useful. In this hospital, although there was a policy that theft of narcotics should be investigated, there were no adequate mechanisms in place to deal with theft of patients' medications or possible resulting adverse events.
Read, 1975[25]	Unclear	Intervention	An evaluation study, recording time, costs, laboratory cultures, medication errors & global evaluation of a new procedure compared to the old procedure	A programme of preparing respiratory therapy solutions and medications administered by the respiratory therapy department in a tamper-proof, disposable, unit-of-use package was developed and evaluated.	The evaluation indicated that: personnel costs between the two systems were similar; patient charges increased under the unit dose system by approximately 10 cents per dose; packaging technique and controls improved under the unit dose system; and medication errors were reduced.

Tampering with clinical practice (PRA)

Only one study fitted into the 'PRA' category.[27] This study was carried out in Israel in 1999 and focussed on the accurate detection of digoxin intoxication from post-mortem examination, by measurement of digoxin-like immunoreactive substances (DLIS). The study was based on a series of laboratory tests. It was stated that the findings of the study had medical-legal implications, in cases where erroneous dosing of digoxin or malicious administration were suspected causes of death. However the interpretation of measurable postmortem digoxin concentrations in the therapeutic range should be done with caution. This may have implications for the NHS in cases where patients have died and it is suspected that this could be due to malicious acts.

Table 16: Summary table included studies (PRA)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Bentur, 1999[27]	Israel	Detection	Laboratory tests Pre- and post test study	To determine whether digoxin-like immunoreactive substances (DLIS) can be present after death in critically ill patients not treated with digoxin, whether a postmortem increase in DLIS is detectable and whether sampling site affects DLIS concentrations.	The results of this study have medical-legal implications in cases where erroneous dosing of digoxin or malicious administration are suspected causes of death. The interpretation of measurable postmortem digoxin concentrations in the therapeutic range should be done cautiously. In patients not previously treated with digoxin such a level may reflect the antemortem presence of DLIS rather than indicating an intoxication with digoxin. The finding of toxic digoxin levels warrants further investigation for elucidating their source. In patients treated with digoxin, the finding of postmortem toxic levels in the absence of antemortem levels hinders interpretation because it is not clear whether they reflect postmortem redistribution or true intoxication.

Tampering with/or sabotage of laboratory tests (TES)

Twenty studies or articles fitted into the 'TES' category.[28-47] Seventeen focussed on the detection of adulterants used to sabotage a positive test result for illicit drugs, sixteen of which were based on laboratory tests,[28,29,31,32,34,35,37,38,40-47] and one was classified as an uncontrolled pre-post test study.[33] Four of the laboratory test studies used a control group.[31,41,44,47] Two studies focussed on identifying the extent of the tampering problem: one was a controlled study to assess whether handling food for prick-prick (allergy) tests with latex gloves interfered with the results in patients with latex allergy.[36] The other used a questionnaire to investigate non-adherence in patients with diabetes treated by insulin pump, who were suspected of tampering with their blood or urine samples.[39] The remaining study was an uncontrolled pre-post test study examining the outcome for children who had undergone a family psychiatric intervention, in cases of factitious illness by proxy.[30]

Fifteen of the studies were carried out in the USA, with one each in Sweden, the UK, Spain, Czech Republic and South Africa. Most studies were published later than 1995.

Table 17: Summary table methods (TES)

Methods	Laboratory tests: uncontrolled or unclear	Laboratory tests: controlled	Uncontrolled pre-post test design	Controlled study	Questionnaire
Number of studies	12	4	2	1	1

Table 18: Summary table place of study (TES)

Country	USA	UK	Sweden	Spain	Czech Republic	South Africa
Number of studies	15	1	1	1	1	1

Table 19: Summary table year of publication (TES)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 and later
Number of studies	0	1	1	3	8	7

Implications

Adulteration of urine with various products was reported. Of these adulterants, 'Stealth' would not be detected by routine assays but was unlikely to alter the result of the urine test anyway.[32] Dilution of

urine with water may lead to false negative results.[33] It is unclear whether the Adultacheck urine strip could detect dilution of urine.[29] Household bleach,[28] pyridinium chlorochromate (Urine Luck)[44] and liquid hand soap[42] may give false-negative results. The methods tested in three studies (ORALscreen system,[45] capillary ion electrophoresis[46] and the methylene blue method[47]) were effective for detecting adulterants in urine. In one study it was recommended that the test be used in conjunction with other indicators such as the physical presence of unusual foaming and/or odour (for detection of adulteration by detergents).[47] Direct observation of urine collection is recommended as not all adulterants can be detected.[35, 37]

In the intervention study of family psychiatric interventions for parents who falsify their children's medical tests (Munchausen's syndrome by proxy), it was concluded that the outcome for reunited children in families who received psychiatric interventions compared well with reported untreated cases, but long-term follow-up is necessary to ensure the child's safety.[30]

The prevalence study of latex allergy confirmed the importance of manipulating foods with vinyl or other non-latex gloves to avoid false prick-prick test results.[36]

The prevalence study of non-adherence in patients with diabetes confirmed that non-adherence (at least occasional) is a relatively frequent phenomenon in patients with type I diabetes.[39]

Implications for the NHS

There are no obvious implications for the NHS with regards to patient safety.

Table 20: Summary table of included studies (TES)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Baiker, 1994[28]	USA	Detection	Laboratory testing	To report the effects of small amounts of bleach on known concentrations of tetrahydrocannabinol (THC) when measured by radioimmunoassay (RIA), fluorescence polarisation immunoassay (FPIA), and gas chromatography/mass spectrometry (GC/MS).	Very small amounts of household bleach can significantly affect the quantitation of THC by both immunoassays and GC/MS. All three methods show some effect at any given level of bleach.
Barrett, 2001[45]	USA	Detection	Laboratory tests	To report the results of field evaluations of the ORALscreen System for screening of drugs in oral fluid.	The advantages of the ORALscreen over a laboratory-based urine screening test include: results obtained at the point-of-collection in minutes, no need for special collection facilities, observed sample collection and no requirement for special laboratory equipment or reagents.
Beck, 2000[29]	Sweden	Detection	Laboratory tests	To check for urine adulteration in a Stockholm clinic for young people with drug abuse problems.	The Adultacheck strip might be useful in detecting dilute urine specimens already at the clinic, though the test strip levels did not agree well with the respective laboratory results. Adulteration of urine specimens was not common at the clinic, and specimen collection for urine drug testing could be performed in a reliable manner.
Berg, 1999[30]	UK	Intervention	Uncontrolled pre-post study	To determine the outcome for children after psychiatric intervention in cases of factitious illness by proxy (Munchausen's syndrome by proxy).	Family reunification is feasible for certain cases, but long-term follow-up is necessary to ensure the child's safety and to identify deterioration in parent's mental health. The outcome for reunited children compared well with reported untreated cases.
Cody, 2001[31]	USA	Detection	Laboratory testing: controlled study using samples	An analysis of morphine and codeine in samples adulterated with Stealth (an adulterant used to avoid detection of drug abuse).	It is important to consider this procedure as an option for samples that screen positive but the opiates and their respective internal standards are not recovered for GC-MS analysis.
Cody, 2001[32]	USA	Detection	Laboratory testing	To assess the effect of the adulterant "Stealth" (a peroxidase) on various clinical parameters and immunoassay testing for drugs of abuse.	Addition of Stealth to urine samples would not be detected by current routine analyses designed to identify adulterated specimens.
Cone, 1998[33]	USA	Detection	Uncontrolled pre-post test	To investigate the effects of excessive fluid ingestion on immunoassay test results following marijuana and cocaine administration.	It was concluded that claims of 'flushing' and 'cleansing' for the herbal products were not accurate and that ingestion of large amounts of water was responsible for the production of false-negative urine test results.
Critchfield, 1993[34]	USA	Detection	Laboratory testing	To test whether an antibody-mediated interference could arise in a homogeneous immunoassay used to determine the presence of cocaine metabolites in urine.	Whether antibody-mediated interference is a practical problem at the present time is unknown. It may be difficult to detect excess interfering antibody by using some traditional tests for urine adulteration.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
					Further investigation of these findings may help to delineate the possible magnitude of the problem and provide methods less susceptable to this potential interference.
Ferslew, 2001[46]	USA	Detection	Laboratory testing	To test the application of capillary ion electrophoresis (CIE) for the direct detection of anionic concentrations in normal human urine and urine speciments suspected of adulteration.	CIE is applicable to forensic analysis of urine anion concentrations. CIE can easily quantitate numerous endogenous anions and offers a method to detect and/or confirm anion adulteration of urine specimens.
Jones, 2000[47]	USA	Detection	Laboratory testing: controlled study using samples	To determine whether the methylene blue method was suitable for the detection of anionic surfactants (detergent) in forensic urine drug test specimens that were suspected of adulteration.	The extent of interference depends upon the type of immunoassay reagent used, the pH of the specimen, the concentration of other constituents in the specimen, the concentration of the surfactant, and the type of surfactant used. This analysis for detecting anionic surfactants in urine can be used along with other indicators such as the physical presence of unusual foaming and/or odor to support the forensic determination that a specimen is adulterated by a detergent.
Mikkelsen, 1988[35]	USA	Detection	Laboratory tests	To investigate eight readily available substances claimed to cause false-negative results when added to urine that would otherwise test positive by the EIA screening assays for illicit drugs. To identify effective means of detecting urine specimens that are contaminated so that an unadulterated specimen may be obtained.	The adulterants interfered somewhat differently with each of the drug assays. EIA assays for illicit drugs can be invalidated by specimen adulteration producing false-negative results. Therefore, if urine drug testing is to be conducted, pH, relative density and appearance should be assessed and suspect specimens should be rejected. Not all adulterants can be detected, so observed collection is strongly recommended.
Sanchez-Lopez, 2000[36]	Spain	Prevalence (extent of problem)	Controlled study	To prove that handling fresh foods prepared for prick-prick tests with latex gloves can tamper with the results in patients with latex allergy.	Confirms the importance of manipulating foods with vinyl gloves or other material containing no latex in order to avoid false results.
Schwartz, 1985[37]	USA	Detection	Laboratory testing: uncontrolled longitudinal study	To report on experience with a photometric immunoassay to measure urinary cannabinoids (marijuana).	The specificity of the method for detecting recent marijuana use appears excellent; the sensitivity depends on the potency, time of last use, frequency of previous use, and specific gravity of the urine specimen. Unless samples are collected under direct observation, urine colour, temperature, specific gravity, and dipstick tests for blood and pH should also be recorded.
Schwarzhoff , 1993[38]	USA	Detection	Laboratory testing	A battery of adulterating agents previously tested against radioimmunoassay (RIA) were	The FPIA test is susceptible to specimen adulteration, but the susceptibility is unique to the particular chemical agent

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
				evaluated in a similar format using fluorescence polarisation immunoassay (FPIA).	and to the specific drug test. Although the results of pH measurement on adulterated samples verified its utility in identifying some samples adultered with interfering agents, other adulterants that cause substantial effects would not be identified by pH measurements alone.
Stechova, 2002[39]	Czech Republic	Prevalence (extent of problem)	Survey: questionnaire (uncontrolled cohort)	To investigate non-compliance in diabetic patients treated by insulin pump. Patients suspected of tampering with their own blood sugar or urine test samples to avoid detection.	The results of the questionnaire confirm the authors' experience that non-compliance (at least occasional) is a relatively frequent phenomenon in the group of type 1 diabetes patients.
Tsai, 1998[40]	USA	Detection	Laboratory screening tests	To investigate the effect of high concentrations of nitrites on the detection of five commonly abused drugs by immunoassay screening and GC-MS analysis.	The problem of nitrite adulteration could be alleviated by sodium bisulfite treatment even when the specimens were spiked with 1.0M of nitrite ion.
Tsai, 2000[41]	USA	Detection	Laboratory tests: controlled study using samples	To investigate the influence of both urine sample matrix and the duration of nitrite exposure on nitrite interference of a cannabinoid (THCCOOH) detection.	The decrease or loss of immunoassay detectable cannabinoid cross-reactives in acidic 'THC-positive samples' can be attenuated by chemically increasing the pH value of the samples to the basic pH range.
Uebel, 2002[42]	South Africa	Detection	Laboratory screening tests	To investigate the influence of household chemicals used to adulterate test results of urine samples that tested positive for cannabis or methaqualone (Mandrax)	Hand soap, which is commonly available in most public toilets, gave false-negative results for both tests.
Urry, 1998[43]	USA	Detection	Laboratory tests and literature review (non-systematic)	To identify all sources of nitrite in urine and the range of concentrations associated with these sources and to determine if nitrite adulteration can be supported based on a quantitative result.	A quantitative measurement of nitrite by a well-structured assay can provide scientifically valid and forensically defensible proof of adulteration with a nitrite-containing substance.
Wu, 1999[44]	USA	Detection	Laboratory testing: controlled study with samples	To examine the effect of pyridinium chlorochromate (PCC) found in the product 'Urine Luck'.	PCC is an effective adulterant for urine drug testing of THC and opiates. Identification of PCC use can be accomplished with use of a spot test for the oxidant.

Tampering with records (REC)

Three studies fitted into the 'REC' category.[48-50] The one non-intervention study investigated how a theft of special nuclear material could be disguised by tampering with the bookkeeping in a material accounting system. The study was carried out in the USA and it was published over 20 years ago.[48] Of the studies which focused on interventions or solutions to prevent or deal with the tampering of records, one study presented a technique for watermarking documents to prevent tampering[49] and the other article investigated the security of data processing systems in hospitals.[50] The watermarking study was carried out in Taiwan in 2001[49] and the risk assessment article was published in France in 1982.[50]

Table 21: Summary table methods (REC)

Methods	Risk assessment	Intervention	Detection
Number of studies	1	1	1

Table 22: Summary table place of study (REC)

Country	France	Taiwan	USA
Number of studies	1	1	1

Table 23: Summary table of year of publication (REC)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 & later
Number of studies	1	1	0	0	0	1

Implications

The non-intervention study[48] presented a theoretical model of the interactions between an accounting system and potential tamperers. It was suggested that the results of the analyses would identify the weaknesses in the bookkeeping structure of the material accounting system and offer possible modifications for 'hardening' those weaknesses. It is doubtful that the information presented in this article has any relevance to current bookkeeping practice as it was published over 20 years ago, and has no obvious implications for the NHS. The watermarking study[49] reported that the technique proposed was more reliable and robust to malicious attack than conventional techniques, such as JPEG images and that the method was able to tolerate some incidental distortions. The risk assessment of data processing systems[50] identified vulnerable points such as physical access to the

computer, manipulation of information during data-entry, and access to the information. It also outlined the costs of setting up an effective safety programme.

Implications for the NHS

The watermark study may have implications for the NHS in relation to the protection of paper and electronic patient records from tampering. The risk assessment study in the French hospital setting is of limited interest as it was carried out 20 years ago. The cost data it presented would need to be recomputed for current equipment and systems and for the organisational differences between French and UK healthcare systems. The findings from the analyses carried out in the modelling study would not be directly applicable to the NHS.

Table 24: Summary table of included studies (REC)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Gwo-Jong, 2001[49]	Taiwan	Intervention	Proposal and description of a technique	The authors propose a mean quantitisation based fragile watermarking approach that can be used to judge the credibility of a suspect image.	This image authentication scheme is able to detect malicious tampering while tolerating some incidental distortions.
Lim, 1979[48]	USA	Detection	Theoretical model	To present a methodology that yields the combinations of ways an adversary may disguise a special nuclear material (SNM) theft by tampering with the bookkeeping in a material accounting system.	Consequently, the results of the analyses would identify the weaknesses in the bookkeeping structure of the material accounting system and suggest possible modifications for 'hardening' those weaknesses.
Roudnitzky, 1982[50]	France	Risk assessment	Discussion paper	Discusses security of data processing systems in hospitals	It is suggested that every hospital region should develop a safety chart containing the relevant principles and methods of safety management.

Organisational factors associated with sabotage/ tampering (ORG)

Nineteen studies were identified which fitted into the category 'ORG'.[51-69] Ten focussed on factors which might cause or foster the development of sabotage or tampering within the workplace.[51-55,58,61, 62, 64, 65] Of these, three were non-systematic literature reviews,[51,58,65] four were questionnaire surveys,[52,54,61,62] one was based on interviews,[64] one was a theoretical model used to demonstrate mechanisms that sabotage the emergence of full mutual cooperation,[53] and one was an observational study.[55] Seven studies focussed on identifying the extent of the sabotage or tampering problem within organisations.[56, 57, 59, 60,63,66,68] Of these, three were non-systematic literature reviews,[56, 57, 68] one was a qualitative analysis of interviews,[60] one was a rating-scale development study,[59] one used a questionnaire and Delphi technique[66] and one was an observational study.[63] Of the remaining two studies, one assessed via a questionnaire an intervention for sensing a crisis or sabotage event and then managing the problem so that a full crisis was averted[67] and the other used content analysis of business communications to investigate the impact of organisational-level variables on individual decisions about sabotage or tampering.[69]

Sixteen of the nineteen studies were published in the USA with one each published in the UK, Canada and Australia. Most of the studies were published after 1990.

Table 25: Summary table methods (ORG)

Methods	Literature review (non-systematic)	Content analysis	Survey: questionnaire	Survey: other or unclear	Theoretical model	Observa-tional study	Rating scale development	Inter-views
Number of studies	6	1	6	1	1	2	1	1

Table 26: Summary table place of study (ORG)

Country	USA	UK	Australia	Canada
Number of studies	16	1	1	1

Table 27: Summary table date of publication (ORG)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 or later
Number of studies	2	0	3	6	3	5

Implications

In an observational study at a meat plant, it was found that although sabotage did not appear to be a major problem, it did exist and there appeared to be several norms (both formal and informal) concerning what was acceptable and what was not.[63] Another study which assessed the extent of the problem found that sabotage behaviour in frontline services affected performance and also had a number of psychological and emotional consequences for the employee.[56] Yet another study reported that group morale may be usefully measured by means other than self-report indices.[59]

Other studies that focussed on the cause of sabotage or tampering reported a range of likely factors. These included perceptions of powerlessness, which were found to be a frequent cause of sabotage, and that saboteurs did not randomly engage in sabotage activities, but targeted their behaviour at the perceived source of injustice.[51] One study reported that results established in the frustration field should be of interest to researchers in the job stress domain.[52] Frustration was found to be related to sabotage in two studies.[61,70] One study concluded that temporary employment may reduce organisational efficiency by creating conditions that stifle active expressions of employee resistance.[64] Data collected from an observational study did not support the contention that the participation scheme found in modern Japanese management increases worker control.[55] In one study, inequity at work led, in most cases, to workers approaching the union or filing a complaint, rather than to sabotage or theft.[60]

Suggestions arising from the studies for interventions at the organisational level to prevent sabotage were varied and included clarification of the role of self-preservation in sabotage with particular importance placed on developing investigations which help management to recognise and deter the saboteur[54] and the implementation of information systems which allows for less rational displays of resistance, such as passive resistance misuse.[58]

One study reported that a team approach to the problem of workplace property violence may be optimal to prevent or reduce sabotage in the workplace.[57] One study found that human resource managers directed to observe worker conflict helped to reduce tension-causing situations (between managers and employees) and subsequent risks of sabotage, using interpersonal and organisational structure approaches.[66] In another study acts of sabotage were found to be premeditated and therefore it was suggested that attempts to determine who causes sabotage are more important than what is sabotaged or why.[66] In another study it was reported that as part of building any comprehensive intervention plan, management should continue to promote security awareness within its employer-employee relationships.[67] In building a comprehensive intervention plan, one study suggested that management should continue to promote security awareness within its employer-employee relationships.[67] One study found that employees of both public and private sectors are cognisant of the causes of workplace violence and aware of how to prevent it; however only 20 participants were surveyed.[68] Another study concluded that corporate documents do contain moral reasoning - stages of moral reasoning used varied according to situation and nature of harm.[69]

Implications for the NHS

Possible implications for the NHS arising from the organisational studies centre around reducing the amount of frustration and inequity (perceived or otherwise) in the workplace**,** effective management of worker conflict, reducing tension-causing situations, formulating policy documents which contain moral reasoning and promoting security awareness.

Table 28: Summary table included studies (ORG)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Abbott, 2001[65]	USA	Causation	Literature review (non-systematic)	To analyse employee knowledge about workplace factors that relate to employee job satisfaction, as well as the saliency of these facts for the individual.	The information from this research could inform personnel managers and other supervisors as to the motivating factors for employees doing harm within the working environment.
Ambrose, 2002[51]	USA	Causation	Literature review (non-systematic)	To examine the relationship between injustice and workplace sabotage.	Saboteurs are more likely to 'miss their mark' when they target individuals than when they target organisations. The research suggests that primary causes of sabotage are workplace phenomena that can be managed. Research on justice provides useful guidelines for increasing workplace fairness. Because powerlessness was the second most frequent cause of sabotage, research on empowerment may also provide a useful framework for managing sabotage. When the structure of procedures is unfair, individuals are as likely to perceive this as taking from them something they deserve (restoration) as they are to perceive themselves as being harmed (retaliation). The results suggest that saboteurs do not randomly engage in sabotage activities, but target their behaviour at the perceived source of the injustice.
Chen, 1992[52]	USA	Causation	Questionnaire survey	To investigate, based on findings from the domain of organisational frustration, the conceptual similarity between stress and frustration and the functional similarity between frustrated events and work stressors, the relationships of behaviours (aggression, withdrawal, theft and substance use) with work stressors and affective reactions.	Authors state that their design makes it impossible to draw any causal inferences about the impact of stressful job conditions on behaviours. From a theoretical perspective, they speculate that work stressors may interfere with individuals' goal attainment or maintenance as frustrated events do. The interference can be frustrating or arousing to employees, making people irritable or annoyed, and triggering aggressive behaviours. If this speculation were true, results established in the frustration field should be of interest to researchers in the job stress domain.
Darwen, 2001[53]	Australia	Causation	Theoretical model	To demonstrate two mechanisms that sabotage the emergence of full mutual cooperation.	Unclear as to implications.
DiBattista, 1991[66]	USA	Prevalence (extent of problem)	Questionnaire: Delphi technique	To examine a list of sabotage forms found in the workplace today, develop reasons for the sabotage, and create methods for reducing the risk of sabotage events.	The findings direct human resources managers to observe worker conflict and help reduce tension-causing situations between managers and employees. Strategies focus on implementing interpersonal approaches and organisational structure approaches to reduce the risk of sabotage.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
DiBattista, 1996[67]	USA	Intervention	Survey: Questionnaire	To present a method for sensing a crisis or a sabotage event and then manage the dilemma so that a full crisis is avoided.	Although recognition and deterrence procedures may be in place in some cases, sabotage acts are deemed to be premeditated. Thus, it is more important to determine who causes sabotage than what is sabotaged or why. In building a comprehensive intervention plan, management should continue to promote security awareness within its employer-employee relationships. This aspect of training will produce a significant payoff to the organisation compared to costs incurred in events that reach the acute and chronic states.
Giacalone, 1987[54]	USA	Causation	Survey: questionnaire	Using the process of accounting as a basis, the present study investigated whether the a priori reasons a person has for the acceptability of sabotage will result in a greater likelihood that they will justify sabotage within an organisation. Specifically, the study investigated whether individuals who will accept more reasons for sabotage will justify sabotage more highly than those who do not.	The present study provides for a variety of future investigations which should help to clarify the role of self-preservation in sabotage. Specifically, the authors propose an emphasis on two areas: the relationship between sabotage justifiability and actual sabotage, and the role of individual differences in sabotage propensity. It is the authors' opinion that particular importance ought to be placed on developing those investigations which help management to recognise and deter the saboteur and his costly acts, as opposed to studies dealing with the genesis of the problem.
Giesberg, 2001[68]	USA	Prevalence (extent of problem)	Survey and literature review	To use evidence from prior studies and field interviews to develop an effective focus and a full understanding of corporate sabotage.	It can be concluded that employees of both public and private sectors have a better grasp of which sector has a propensity for committing workplace violence. Not only are the employees from the various sectors cognizant of the causes of workplace violence, they are also aware of how to prevent it. This was a very large topic with sweeping conclusions based on a survey of only 20 participants in the USA.
Gillespie, 1995[69]	USA	Content analysis	Content analysis of business communications	To investigate the impact of organisational-level variables on individual decisions.	This may have implications in analysing NHS policy documents or reports on the prevention or investigation of sabotage and/or tampering in the UK setting.
Graham, 1993[55]	USA	Causation	Observational study	To identify patterns of behaviour that reflect the relationship among workers and between workers and management in their day-to-day work experience.	Data collected from this case study do not support the contention that the participation scheme found in modern Japanese management increases worker control. This was true technically and politically. The research raises the question of whether the existence of formal structures is a reliable measure for determining the successfulness of intraorganisational transference, particularly when a distinctive feature of that organisation is employee commitment, identification, and loyalty.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Harris, 2002[56]	UK	Prevalence (extent of problem)	Literature review	To explore, describe, and classify the deviant and counterproductive actions of frontline, customer-contact service providers, and also model the antecedents and consequences of such actions.	The study revealed that frontline service sabotage behaviour affects performance and also has a number of psychological and emotional consequences for the employee. The authors attempted to construct a theory from this work and the next stage of theory testing is left for future studies.
Klein, 1996[57]	USA	Prevalence (extent of problem)	Literature review (non-systematic)	To investigate employee destruction of organisational products or property.	The authors have only introduced organisation behaviour concepts that may be helpful in the evaluation of workplace sabotage. A thorough evaluation of workplace sabotage needs the expertise of both the mental health professional skilled in the evaluation of individual psychopathology and the consultant knowledgeable in organisational behaviour. A team approach to this problem of workplace property violence may be optimal to attain a satisfactory biopsychosocial evaluation and subsequently prevent or reduce sabotage in the workplace.
Marakas, 1996[58]	USA	Causation	Literature review (non-systematic)	To focus attention on a form of covert resistance to the IT implementation process that is neither couched in criminal intent nor motivated by personal gain.	The authors argue that the necessary interpersonal competence for successful IS implementation must allow for less rational displays of resistance, such as PRM, than have been previously acknowledged. By recognising the potential for PRM behaviour we may be more able to create an atmosphere in which people become less inhibited to voice these expressions of fear.
Motowildo, 1977[59]	Canada	Prevalence (extent of problem)	Development of rating scales	To determine the feasibility of extending scaled-expectations methodology into the realm of morale measurement, to develop systematic procedures for assessing group morale without unduly restricting the measuring instrument to any of the several definitions that appear in the literature.	These results lend some support for the notion that group morale can be measured by means other than self-report indices. Behavioural-scaling methodology, which has been used in the past primarily to assess job performance, shows promise as an approach for measuring group morale. This methodology should be further explored as an alternative to self-report measures in other organisational contexts besides the military.
Sieh, 1987[60]	USA	Prevalence (extent of problem)	Interviews and qualitative analysis	To discover the rules, plans, conventions, images and so forth that people use to guide their behaviour (with regard to injustice and sabotage at work)	Inequity at work led in most cases to workers approaching the union or filing a complaint, rather than to sabotage or theft.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Spector, 1975[61]	USA	Causation	Questionnaire	To: a) measure frustration in an organisational setting, and b) examine some correlates of that frustration. It was hypothesised that greater frustration experienced by an employee on the job would be associated with more reports from the employee of performing potentially detrimental behaviours such as complaining or sabotage.	The authors state that although the current study was correlational and based on self-report data, it supports the contention that frustration in an organisational setting can have extremely negative effects on the behaviour of persons in that organisation. To the extent that considering quitting and actually quitting a job are related, frustration would be related to turnover. In addition, the complaints and hostility expressed by employees would adversely affect the organisational climate. Frustration was also found to be related to sabotage.
Storms, 1987[62]	USA	Causation	Survey: questionnaire	To examine the influence of organisational frustration and locus of control on emotional and behavioural reactions to frustrating conditions.	The organisation used in this study provided human services, and one might expect a low level of some aggressive types of behaviour. The reactions data were collected through self-report measures so there may have been under-reporting since some respondents may not have reported acts of sabotage, vandalism or theft. The authors state that support for the organisational frustration-behavioural reaction relationship is quite clear: frustrating work conditions can lead to counterproductive behavioural responses.
Thompson, 1993[63]	USA	Prevalence (extent of problem)	Observational study	To analyse how workers interact with one another on the job, how they cope with the strains of the work, how they maintain a sense of self-worth, and how they develop and maintain informal norms in regard to customer spending.	Although sabotage did not seem to be a major problem at the beef plant, it did exist, and there appeared to be several norms (both formal and informal) concerning what was acceptable and what was not. Working at the beef plant was "dirty work". It was monotonous, difficult, dangerous, and demeaning. Despite this, the workers at the beef plant worked hard to fulfil employer expectations in order to obtain financial rewards. Through a variety of symbolic techniques, they managed to overcome the many negative aspects of their work and maintain a sense of self-respect about how they earned their living.
Tucker, 1993[64]	USA	Causation	Survey	To examine how employees pursue grievances against their employers, and in particular, temporary employees.	Despite its apparent economic benefits, temporary employment may ultimately reduce organisational efficiency by creating conditions that stifle active expressions of employee resistance.

Tamper-evident packaging (TEP)

Three studies were identified which fitted into the 'TEP' category[71-73] and all three focussed on tamper-evident packaging as an intervention. Two were published in the UK[71,73] and one in the USA.[72] The two UK studies were non-systematic literature reviews, one on labelling of products[71] and one on the tamper evident packaging industry in general.[73] The USA study was a discussion paper followed by a series of uncontrolled experiments to evaluate the utility of various forms of tamper-evident packaging, with volunteers.[72]

Implications

One of the UK reviews was published in 1989 and is likely to be out-of-date in terms of any implications.[73] It speculates about the future growth of the tamper-evident packaging industry. The other literature review and study both advocated better labelling of products.[71, 72] The review proposed that child-resistant closures should be used on all household and garden chemical packs which are labelled as being harmful, irritant, or where a statement is included that medical advice should be obtained if the product is swallowed.[71] The study noted that statements on the packaging which inform the consumer about the tamper evident feature must be legible and that there must be better instructions for use of the package.[72] This study also proposed four elements of a programme for achieving effective tamper evidence which were package design, specification, consumer education and performance evaluation. The tamper-evident design must be based on a realistic assessment of what the consumer can and will do to participate in the detection process.

Implications for the NHS

In particular the findings of the study which sets out improvements for tamper evident packaging may have implications for the NHS, in terms of tamper-evident packaging for medical equipment and drugs.

Table 29: Summary table included studies (TEP)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Department of Trade and Industry, 1999[71]	UK	Intervention	Non-systematic ('technological') review	To review available child-resistant closures (CRCs) and tamper-evident devices, and to look at their penetration in the market place and issues related to their production and use.	The somewhat arbitrary nature of decisions of whether or not to fit a CRC could be rationalised by Codes of Practice advocating the use of CRCs on all household and garden chemicals packs which are labelled harmful, irritant, or where a statement is included that medical advice should be obtained if the product is swallowed.
Lockhart, 1997[72]	USA	Intervention	Discussion paper/ equipment evaluation by uncontrolled trials	To describe measurement and statistical treatment of the successes and failures of people to detect tampering and suggest ways to increase the success rate for detections.	Four elements comprise a programme for achieving effective tamper evidence: package design, specification, consumer education and performance evaluation. The design must be based on a realistic assessment of what the consumer can and will do to participate in the detection process. There must then be proper specification of the design so that it is correctly made. There is a description of performance evaluation. The author notes that statements on the packaging informing the consumer what the tamper evident feature is must be legible. Requirements for tamper evident packages which have not been presented until now are: consumer education; packages that are easy for consumers to diagnose; limit variety of systems; reduce rate of packing change; and better instructions for use.
Paine, 1989[73]	UK	Intervention	Non-systematic review	Objective appears to be to review the literature on tamper-evident and tamper-resistant packaging.	The literature indicates that one of the growth areas for development in the future will be in the area of security packaging including tamper evidence, especially for food. This will be reinforced by the expansion of original pack dispensing and over the counter sale of drugs and medicines, and the extension of security packaging in the food, cosmetics, toiletries and household goods fields, the last three being possibly prompted by legislation on child resistant packaging requirements and product liability. As far as drugs and medicines are concerned the present guidelines in a number of countries may well be raised to a mandatory level but in the food distribution field legislation does not at the moment seem likely. Voluntary codes of practice or guidelines will probably be introduced in some countries which at present have none.

Tampering with food (FOD)

Seventeen studies were identified that fitted into the category 'FOD'.[74-90] Sixteen were focussed on the detection of adulterants in food and all but one used laboratory test methods;[74-80, 82-89] this study was an evaluation of a process.[90] The remaining study focussed on risk assessment (via a theoretical model) to assess the threat of wilful tampering with public water systems.[81] Eight of the seventeen studies were carried out in the USA,[75,78,79,81,86,88-90] two in India,[80,82] two in Switzerland[84,85] and one each in Australia,[74] France,[76] Ireland,[77] Spain[87] and Slovenia.[83] Most studies were published after 1990.

Table 30: Summary table methods (FOD)

Methods	Laboratory tests: uncontrolled or unclear	Laboratory tests: controlled	Equipment/ process evaluation	Risk assessment: theoretical model
Number of studies	14	1	1	1

Table 31: Summary table place of study (FOD)

Country	USA	India	Switzerland	Australia	France	Ireland	Spain	Slovenia
Number of studies	8	2	2	1	1	1	1	1

Table 32: Summary table date of publication (FOD)

Date of publication	1980 or earlier	1981-1985	1986-1990	1991-1995	1996-2000	2001 or later
Number of studies	1	1	2	4	5	4

Implications

A range of methods was outlined for the detection of adulterants in food, in this set of studies. One of these was the stable carbon isotope ratio analysis (SCIRA) which was reported to be a powerful method for determining adulteration by C4 sugars in fruit juices. However, variation due to measuring technique was found so it is important to carefully calibrate the system, based on a large number of known samples, before analysing unknown samples.[74] Another method was the SEM X-ray analysis which was found to be a useful technique to examine extraneous materials in food such as glass. Detection is via the chemical and physical changes in food products.[75] A study of differential scanning calorimetry reported that adulteration of honey by industrial syrup appeared to be detectable from a level as low as 5%.[76] A study of visible and near-infrared spectroscopy to detect and quantify

sunflower oil adulteration in extra virgin olive oils reported that although the level of accuracy in the study was suitable for industrial use, the results require extension to a greater number of samples before they can be completely endorsed.[77]

Two studies of a chiral LC method for detecting adulteration of apple juice with DL-malic acid reported that the method could detect adulteration at lower levels than previously reported.[78, 79] Another method (capillary electrophoresis with direct UV detection) was found to be useful in assessing adulteration of orange juices.[87] A spectrophotometric process to detect menthol in samples of Pan Masala led to the recommendation that good manufacturing practice should be adopted so that the Pan Masala samples do not exceed 0.1% menthol concentration.[80] A technique for detecting an amino acid in Lathyrus sativus (present in flour) was found to be useful by the India Society of Public Analysts.[82] Methods for detecting adulteration or watering of Slovenian wines were found to be useful only when used concurrently and further research was recommended.[83] Two studies using anion-exchange methods found the technique to be useful for detecting adulteration of coffee.[84, 85] Fourier-transformation near-infra-red spectroscopy was found to be of potential value in detecting ricin contamination of flour.[86] A method of characterising the glass of jars and of fragments found in baby food was found to be valuable for determining the origin of the glass fragments, and the authors recommended that a database be established for other types of glass.[89] A study about misbranding of ice cream did not appear to have any implications with regard to sabotage or tampering.[88]

The process evaluation study involving foodservice managers, found that managers' levels of awareness of food tampering could be increased and they could be made more receptive to making operational changes to reduce the risk by communicating food tampering risk reduction information.[90] The study that carried out a probabilistic risk assessment of the threat of wilful tampering to public water systems was reported to be useful as a way of informing decision makers about how best to harden systems against potential tampering.[81]

Implications for the NHS

The implications likely to be of most relevance to the NHS arise from two studies. The study involving a risk assessment of the threat of wilful tampering with water systems suggests that a similar approach could be used to identify areas of vulnerability within hospitals and processes within the NHS. And secondly, the study of foodservice managers' awareness of food tampering may have implications in terms of communication of risk reduction information to all staff. The other studies do not seem to have direct implications for the NHS although some of the techniques described for detecting adulterants could be investigated for potential use if tampering with drugs or hospital food products is suspected.

Table 33: Summary table included studies (FOD)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Antolovich, 2001[74]	Australia	Detection	Laboratory tests	To determine the authenticity of commercial Australian orange juices using stable carbon isotope ratio analysis (SCIRA).	SCIRA is a powerful method for determining adulteration by C4 sugars in fruit juices. These studies indicate that seasonal changes and instrumental operating conditions have little effect on the data. There does however seem to be a variation due to measuring technique and so it is important to carefully calibrate the system based on a large number of known samples to confidently analyse unknown samples.
Charbonneau, 1988[75]	USA	Detection	Laboratory tests	Using scanning electron microscopy and X-ray microanalysis to investigate three typical corrosion problems found in plain tinplate cans and to examine glass and glass-like particles that were found in canned foods.	SEM-X ray analysis is a useful technique to examine extraneous materials in food like glass that may arise from chemical and physical changes in the food product.
Cordella, 2002[76]	France	Detection	Laboratory tests	To use differential scanning calorimetry (DSC) to study the thermal behaviour of authentic honeys (Lavandula, Robinia, and Fir honeys) and industrial sugar syrups.	Under applied conditions, the effects of adulteration of honeys by industrial syrups appeared to be detectable from a level as low as 5%.
Downey, 2002[77]	Ireland	Detection	Laboratory tests: controlled study with samples	To detect and quantify sunflower oil adulteration in extra virgin olive oils from the Eastern Mediterranean by visible and near-infrared spectroscopy.	The authors state that this work has only included a single sunflower oil sample. Natural variations in chemical composition between samples of this oil will occur, for example, between varieties, harvest, and geographic locations. Therefore, the results reported in this work require extension to a greater number of sunflower & olive oil samples before they can be completely endorsed. The level of accuracy in this study is suitable for industrial use.
Eiesle, 1996[78]	USA	Detection	Laboratory tests	To evaluate the analytical performance characteristics of the chiral LC method in a multilaboratory environment and to determine the inter-laboratory variability of the method.	The collaborative study results demonstrated that the method could quantitate the economic adulteration of apple juice with DL-malic acid at lower levels than those reported with previous methods. The LC method for determination of D-malic acid in apple juice has been adopted first action by AOAC International.
Elkins, 1994[79]	USA	Detection	Laboratory tests	To determine the interlaboratory variability of this method of detecting adulteration in apple juice, by collaborative study.	The method can be used to detect nonauthentic apple juice at the concentration of at least 30%. Not very relevant to the NHS.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Kannan, 1997[80]	India	Detection	Laboratory tests	To perform analyses to detect menthol in branded and non-branded samples of Pan Masala by a simple spectrophotometric process.	The results suggest that the addition of menthol is relatively higher in non-branded Pan Masala samples than in branded ones. Good manufacturing practice should be adopted so that the Pan Masala samples do not exceed 0.1% menthol concentration. Study is of questionable relevance.
Lambert, 1997[81]	USA	Risk assessment	Theoretical model	To suggest the use of probabilistic risk assessment to assess the threat of wilful tampering to public water systems.	Such a quantitative risk assessment is useful to inform decision makers on how best to harden the systems against potential tampering.
Look, 1993[90]	USA	Detection	Process evaluation	To determine the level of food tampering awareness and opinions of foodservice managers in commercial and non-commercial foodservice facilities and to obtain descriptive information about the foodservice managers and their facilities. A second objective was to explore if a food tampering risk reduction educational programme based on principles of the Hazard Analysis Critical Control Point (HACCP) system was effective for self-instructional use by managers of foodservice facilities.	The author states that the results of this study can be applied in education and practice in the foodservice industry. It is unclear how these results would apply in the NHS.
Nagarajan, 1967[82]	India	Detection	Laboratory tests	To develop a simple technique for the detection of adulteration of flour with Lathyrus sativus, based on the detection of the amino acid BOAA which is characteristically present in L sativus seed but not in the seeds of other legumes commonly consumed as food in India.	It is felt that the technique detailed here will prove to be of greater use in routine work on adulteration in many public health laboratories in view of its specificity for the detection of L. sativus present as seed or flour in a raw or cooked state. On the basis of preliminary trials, the Society of Public Analysts (India, 1967) has found this technique to be useful.
Ogrinc, 2001[83]	Slovenia	Detection	Laboratory tests	To determine the authenticity, regional origin, and vintage of Slovenian wines using a combination of IRMS and SNIF-NMR analyses.	The usefulness of isotopic parameters for detecting adulteration or watering and to assess the geographical origin of wines is improved only when they are used concurrently. The authors state that further research is needed.
Prodoliet, 1994[84]	Switzer-land	Detection	Laboratory tests	Because adulteration (of coffee) with coffee husks or parchments seems to be relatively widespread, the first aim was to propose a limit for total xylose, the best tracer, above which a soluble coffee should be	Fraudulent addition of coffee husks or parchments in soluble coffee can easily be detected by AE-PAD analysis of total xylose, free mannitol and, to a certain extent, total glucose. About 12% of the 700 samples analysed in this study were beyond the limits.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
				considered as adulterated. The fate of xylose during the roasting and extraction steps was assessed.	
Prodolliet, 1995[85]	Switzer-land	Detection	Laboratory tests	To evaluate the applicability of anion-exchange (AE) chromatography with pulsed amperometric detection (PAD) for the separation & quantitation of the major carbohydrates found in soluble coffee.	The technique is a very powerful tool for routine analysis and for purity assessment of soluble coffee. Not very relevant to the NHS.
Rodriguez-Saona, 2000[86]	USA	Detection	Laboratory tests	To develop a methodology for the rapid detection of castor bean meal, containing the highly cytotoxic protein ricin, in flour-containing products by using FT-NIR spectroscopy and multivariate methods.	Could be used for detection of ricin contamination.
Saavedra, 2000[87]	Spain	Detection	Laboratory tests	To develop, optimise and validate a method for determining isocitric, citric, tartaric and malic acids in natural or commercial orange juices by capillary electrophoresis with direct UV detection and no sample treatment other than dilution and filtration.	The developed method is rapid, simple and reliable for assessing a certain kind of fraud in orange juices, using isocitrate, citrate, malate and tartrate as markers.
Sheppard, 1985[88]	USA	Detection	Laboratory tests	To demonstrate the application of various analytical methods to the detection, identification and quantitation of vegetable oil adulteration of ice cream.	No health or safety issues involved. This study is more about misbranding and adulteration.
Wolnik, 1989[89]	USA	Detection	Laboratory tests	To develop a fast, inexpensive method for characterising both the glass of the jars and the glass fragments found in baby food.	In rare cases where glass entered the product accidentally during production, because baby-food manufacturers attempt to use only one lot of containers for each product code, the adulterant glass should be indistinguishable from the container. This method allows high sample throughput and minimal pre-treament and is reliable. Once databases have been established for other types of glass, classification is possible.

Sabotage or tampering leading to self-harm (SEL)

One study was identified which fitted into the 'SEL' category.[91] It followed the progress of five women with brittle diabetes assigned to using a portable insulin infusion pump. It was published in 1985 and it is unclear where the research was conducted. The relevance of this study to the scoping review is that two of the women deliberately tampered with their insulin pumps, although the reasons for this and the benefits perceived by the women were not given. Therefore, there are no direct implications for the NHS arising from this study other than deliberate tampering with medical equipment can occur.

Table 34: Summary table included studies (SEL)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Williams, 1985[91]	Unclear	Prevalence (extent of problem)	Case series	To test the hypothesis that long-term continuous intravenous insulin infusion (CIVII) delivered by a portable infusion pump will improve glycaemic control in brittle diabetes, using five women with chronically unstable brittle diabetes who had failed to respond to continuous subcutaneous insulin infusion (CSII).	Although CIVII has reportedly been successful in managing brittle diabetes, the technique may not be useful in all individuals with brittle diabetes, as illustrated by the poor glycaemic responses of these patients and the serious complications (including local infection, septicaemia and thrombosis) they suffered. Physicians may be reluctant to accept that failure to respond to treatment may be due to deliberate disruption of treatment by the patient, especially with illnesses such as brittle diabetes which carry an important threat to the quality of life and to life itself. Management remains difficult if manipulation is detected, as exemplified by the departure from care of one patient after a sympathetic discussion about the importance of compliance with CIVII. Although the authors believe that the demonstration, suspicion and/or admission of episodes of deliberate interference with treatment in some participants are important clues to the aetiology of this condition, they are not proof of sole causality.

Educational interventions to prevent sabotage/ tampering (EDU)

One study was identified that fitted into the 'EDU' category.[92] The study was a literature review, published in 2002 in the USA, the aim of which was to identify methods for assessing professional behaviour, largely from a medical education perspective. There were no relevant implications about sabotage or tampering for the NHS, arising from this study.

Table 35: Summary table included studies (EDU)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Arnold, 2002[92]	USA	Prevalence (extent of problem)	Literature review (non-systematic)	To interpret the state of the art of assessing professional behaviour (largely from a medical education perspective).	Without solid assessment tools, questions about the efficacy of approaches to educating learners about professional behaviour will not be effectively answered.

Sabotage of emergency services (EMG)

One study was identified that fitted into the 'EMG' category.[93] The study focussed on the detection of hoax calls to emergency services via the use of voice analysis. Voice analysis was used to determine whether malicious and non-malicious fire alarm callers could be distinguished on the basis of their psycholinguistic attributes. The study was carried out in the UK in 1983. The results showed that malicious and non-malicious calls could be differentiated on the basis of overall speech configuration during the call, and that the analytical approach is viable, although the scoring methods used in the study need to be improved. The authors suggest that although all calls to the brigades must be attended, a method of differentiating hoax calls could help in apprehending and possibly discouraging malicious callers, and propose that further research would be worthwhile. Given that the study was published in 1983, and was the only study identified in this category, it appears unlikely that further research has been carried out. There do not appear to be any direct implications for the NHS in terms of patient safety.

Table 36: Summary table included studies (EMG)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Comber, 1983[93]	UK	Detection	Experiment: Voice analysis	To determine whether malicious and non-malicious fire alarm calls could be distinguished on the basis of their psycholinguistic attributes.	The result of the MSA-I analysis shows that malicious and non-malicious calls can be differentiated on the basis of the overall configuration of speech behaviour within the call. The scoring methods used in this pilot study need to be greatly refined. Nevertheless, the study demonstrates the viability of the analytical approach in that, using even crude measures, malicious calls could be distinguished on the basis of the profile of behaviours presented by such calls. Given the high cost to the public of fire services which deal with malicious calls, further research to clarify these differences would be well worthwhile. Although all calls to the brigades must be attended, a method of differentiating hoax calls could help in apprehending and possibly discouraging malicious callers.

Sabotage at nuclear sites (NUC)

Seventy-six (76) studies or articles fitted into the 'NUC' category.[70,94-168] The majority of articles reported on development or implementation of computer models or decision tree analyses and many were underpinned by the Monte Carlo simulation technique.

Four studies focussed on simulations of sabotage/attack on nuclear facilities. Two of the studies investigated the use of computer simulations to predict the fall-out in, and damage to, local communities.[165,166] Two further studies used theoretical modelling techniques to predict the outcome and implications of internal sabotage.[167,168] Twenty-six articles reported safety assessments of nuclear facilities or areas or systems within nuclear facilities.[97,101,103,105,107,108,114,115,117,119-123,135-137,141,148,150,152,158,159,161-163] Twenty-six were inter-ventions in nuclear facilities or areas or systems within nuclear facilities.[70,95,96,98,104,106,109-112,116,118,124,125,128,130,132-134,138-140,144-147] Fifteen were vulnerability assessments of nuclear facilities or areas or systems within nuclear facilities.[99,100,102,113,126,127,129,131,142,143,153-157] One was a risk assessment using the STAT model[94] and one was a prevalence study based on interviews with experts in the field of threats to nuclear facility security.[149] Three articles centred on detection, one on the viability of underwater seals,[151] one on electronic seals,[164] and one on optical devices for containers.[160]

Table 37: Summary table research focus (NUC)

Methods	Risk assess -ment	Intervention	Emergency planning	Safety assess -ment	Vulnerability assessment	Preva-lence	Detection
Number of studies	1	26	2	28	15	1	3

The majority of the studies were carried out in the USA (n=71), with two in the UK[110,167], two in Germany[136,137] and one in Luxembourg.[144] Most of the studies were published prior to 1995, perhaps reflecting more recent security issues and a reluctance to publish security evaluation results. Later studies tended to focus on the evaluation of tamper-evident seals or labelling equipment.

Table 38: Summary table place of study (NUC)

Country	USA	UK	Germany	Luxembourg
Number of studies	71	2	2	1

Table 39: Summary table of year of publication (NUC)

Date of publication	Not later than 1980	1981-1985	1986-1990	1991-1995	1996-2000	2001 and later
Number of studies	25	15	14	18	3	1

Descriptions of the various modelling techniques used in the studies are listed in the following table. A large group (n=44) of the included studies addressed the development or implementation of theoretical (computer) models.[94,97-103,105-108,113-116,120-123,127,131,136,140-143,145-148,153-159,161-163,165,166,169] There were ten discussion papers,[104,111,112,117-119,128,132,139,167] six equipment evaluations,[70,110,124,125,144,150] two consensus guidelines development papers,[95,138] two computer simulation reports,[135,137] one literature review,[134] one report of a speech,[130] one laboratory test report,[129] two database analyses,[96,168] one cost analysis of RG-17 safeguards measures,[109] one workshop on the application of a modelling technique,[152] one a report of interviews,[149] one mathematical paper using Monte Carlo modelling techniques[133] and three analyses of seal viability.[151,160,164]

The techniques developed or used in the above categories of research were: ASSESS;[141,159,162] BATLE;[142] EASI;[108] ENUMPTH;[122] fault tree analysis;[100,154-156] FESEM;[108] FSNM;[108] ISEM;[97,101,108,114] MAP;[115] MDARS-E;[139] PATHS;[113] PRA;[103,123,153] PREP;[131,163] Project Straight-line;[128] REACT/THERMIX coding;[137] SAFE;[105,107,108,161] SAVI;[158,159] SECURORS;[145] SEES;[141] SNAP;[120,121,148] STAT;[94] SURE;[108] TASK;[147] TDR;[140,143] and VAA.[103] There were nine studies using modelling techniques not specifically named.[98, 99,102,106,126,127,136,145,157]

Table 40: Summary of methodologies used in NUC-S

Method	Description
ASSESS	Analytic system and software for evaluation of safeguards and security
BATLE	Brief adversary threat loss estimator
EASI	Estimate of adversary sequence interruption
ENUMPTH	Enumerating paths an adversary might take to attempt defeat of physical protection systems.
Fault tree analysis	Analysis using logic diagrams to graphically represent the combinations of subsystem and component faults that can result in a specified undesired event.
FESEM	Forcible entry safeguards effectiveness model
FSNM	Fixed-site neutralisation model (a Monte Carlo based modelling technique)
ISEM	Insider safeguards effectiveness model
MAP	Maintainability analysis procedure (a Monte Carlo based modelling technique)
MDARS-E	Mobile detection, assessment and response exterior system
PATHS	Pathfinding simulation procedure (a Monte Carlo based modelling technique)
PRA	Probability risk assessment
PREP	Production risk evaluation program
Project Straight-Line	Monitoring stored nuclear material
REACT/THERMIX	Testing simulator code for computer modelling
SAFE	Safeguards automated facility evaluation
SAVI	Systematic analysis of vulnerability to intrusion
SECURORS	SECURity Office Response Strategies
SEES	Security exercise evaluation simulator
SNAP	Safeguards network analysis (a Monte Carlo based modelling technique)
STAT	Sabotage and tampering avoidance technology.
SURE	Safeguards upgrade rule evaluation
TASK	Target assignment for security officers to K targets
TDR	Time domain reflectometry for checking levels of nuclear material
VAA	Vital area analysis

Implications

Out of the 76 included studies, most presented modelling techniques only. Four studies presented further information about practical implications. One of the two emergency planning studies used an unnamed mathematical method to predict the magnitude and direction of dispersal of radioactive material from a sabotaged nuclear facility.[165] This study established ranges of exposure for facility personnel and local communities, however, these are only theoretical predictions. The second emergency planning study[166] used a computer simulation with data from two controlled spent fuel experiments to estimate the amount of radioactive material released following a sabotage attack using a high energy density device (HEDD). However, this experiment was also only theoretical. The two safety assessments used probabilistic risk analysis (PRA)[167] and a group of three graphics computer programs (FESEM, ISEM and EASI)[168] to assess the nature and likelihood of internal sabotage at a nuclear facility. The analysis with PRA produced doubtful results according to its authors, and the second study found that loss was a higher risk where insider help was available to the saboteurs.

Implications for the NHS

Although many of these studies are not directly applicable to the NHS, some of the modelling techniques could be adapted for the development of methods to investigate insider threats of sabotage in NHS facilities. In particular, addressing issues of internal sabotage being more effective than attack by outsiders, vandalism, theft, and tamper-proof and tamper-evident packaging are of relevance to the prevention of sabotage/tampering in the NHS. Although the majority of the studies in this category are quite old, the techniques they present are likely to be still valid. The assumptions on which the models are constructed would have to be altered to fit the NHS.

Table 41: Summary table included studies (NUC)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Andrews, 1986[94]	USA	Risk assessment	Theoretical model	To evaluate alternatives to the design and operation of nuclear power plants, emphasising a reduction of their vulnerability to sabotage. The scope was to use estimates of core melt accident frequency during normal operations and from sabotage/ tampering events to rank the alternatives.	Vandalism is a major contributor to plant threat. The majority of the more serious of these acts stem from employee malcontent, from mental illness and from political idealism. Data for this category are very limited and may overestimate the threat for power reactors. Most acts have had no offsite consequences and there is no evidence of obvious intent to cause them. There are several methods of dealing with this threat. The first is to reduce vulnerabilities through increased operating flexibility and surveillance. The second is the subject of other NRC actions addressing staff qualifications and access to sensitive areas.
Anonymous, 1988[95]	USA	Intervention	Consensus guidelines	To perform a structured evaluation of existing and proposed vital equipment/ area assumptions, criteria and guidance and to develop a comprehensive and consistent set of recommended assumptions for determining equipment and areas to be designated as vital in nuclear power plants.	Unclear: possibly the need to identify the specific equipment and areas in each plant that require protection as 'vital'.
Anonymous, 1995[96]	USA	Intervention	Database analysis	To check the BFS computerised accounting system capability of performing its major functions as well as to evaluate the accuracy of the database records on nuclear material items characteristics.	None stated. Nothing of relevance to add.
Bennett, 1976[97]	USA	Safety assessment	Theoretical model	The overall methodology and the primary analytic techniques used to assess physical protection system effectiveness (at nuclear facilities) are briefly outlined.	The primary contribution of ISEM is that it provides a consistent framework within which safeguard system effectiveness measures can be generated for the personnel control aspect of the insiders problem.
Bennett, 1975[98]	USA	Intervention	Theoretical model	To report on a dynamic simulation of security force-adversary engagements developed during the US Nuclear Regulatory Commission's Special Safeguards Study.	The experience gained from this model is being applied to a stochastic version of the model which is currently under development.
Berry, 1979[99]	USA	Vulnerability assessment	Theoretical model	To present a technically defendable and conservative fire hazards analysis technique which combines a knowledge of fire phenomena with an understanding of the safety importance of each power plant location.	It is possible to protect a subset of safety-related plant areas and still assure that all fire paths that could threaten safety have been eliminated. It might be possible to break all fire paths of concern by protecting a smaller set of areas which includes non-safety areas through which fire must spread in order to reach the critical combinations of safety areas. This research is on-going.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Boozer, 1976[100]	USA	Vulnerability assessment	Theoretical model and methodology used in nuclear safeguards effectiveness evaluation	To provide a systematic approach to the problem of physical security (of nuclear materials and nuclear facilities).	Not immediately relevant to NHS facilities.
Boozer, 1977[101]	USA	Safety assessment	Theoretical model	To describe the Insider Safeguards Effectiveness Model (ISEM), a simulation model which treats certain aspects of the insider problem (theft or sabotage of radioactive material by people employed in nuclear facilities), and to demonstrate its use in modelling the personnel control system of a hypothetical facility.	Not immediately relevant to NHS facilities.
Boudreau, 1982[102]	USA	Vulnerability assessment	Theoretical computer model	To describe the work done by the Los Alamos National Laboratory for the Vital Area Analysis (VAA) Program.	The authors state that this program will result in the original analysis assumptions either being confirmed or modified. It is expected that the NRC will be able to use the results with greater confidence now that all the vital areas and equipment have been identified. In addition, some of the unnecessary conservativeness of the analyses may be removed and thus reduce the possibility of safeguards requirements adversely affecting the safe operation of the plants. See Varnado[156]
Boughton, 1986[165]	USA	Emergency planning	Theoretical model	To predict magnitude and direction of dispersal of radioactive material from a nuclear facility by sabotage incidents using explosive. For evacuation and sheltering decisions and to estimate the potential size of the clean-up operation.	For exposures greater than 25 rem, respirator protection or evacuation may be required. Sheltering might be considered for levels between 5 rem and 25 rem. Mitigation reduces the critical risk areas by about a factor of 25, which in an urban environment can significantly reduce evacuation requirements. It is estimated that in some cases this may cut cleanup costs from $100s of millions to $10s of millions. This study may be more relevant to terrorism than sabotage.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Buonpane, 1992[162]	USA	Safety assessment	Process evaluation/ theoretical model	To evaluate safeguards effectiveness against the violent intruder	Unclear if any implications for the NHS.
Camp, 1990[103]	USA	Safety assessment	Theoretical model	The objectives of the PRA are to assess the risks to the public and the Hanford site workers posed by the operation of N reactor (a Department of Energy production reactor), to compare those risks to proposed DOE safety goals and to identify changes to the plant that could reduce the risk.	None stated. Appears to exclude sabotage.
Caskey, 1986[104]	USA	Intervention	Discussion paper	To present some of the lessons learned in designing and implementing state-of-the-art high security physical protection systems for a number of government facilities.	May be some relevance to NHS security systems.
Chapman, 1978[105]	USA	Safety assessment	Theoretical model	To describe the Safeguards Automated Facility Evaluation (SAFE) methodology: a reliable, time efficient and easily applied method of evaluating the effectiveness of a (nuclear) safeguards system.	Any fixed facility containing valuable materials or components to be protected from theft or sabotage could be analysed using this same automated evaluation technique.
Chapman, 1975[106]	USA	Intervention	Theoretical computer model	To evaluate a fixed-site safeguard security system using a computer model.	The computer model provides an excellent tool for measuring the cost effectiveness of fixed-site security systems. The validity of the model should improve as better data are found and different site configurations are studied.
Chapman, 1979[107]	USA	Safety assessment	Theoretical computer model	To present the Safeguards Automated Facility Evaluation (SAFE) process for evaluating physical protection systems at nuclear facilities.	From the licensee's perspective, the techniques could be used as a design aid to the licensee and for upgrading to meet certain regulations.
Chapman, 1980[108]	USA	Safety assessment	Theoretical model	To present a brief description of the variety of safeguards evaluation models developed in the areas of global safeguards effectiveness or vulnerability analysis for individual scenarios.	Limitations exist on input data in the detection area and human performance area relative to security officers. The human responses dealing with neutralisation will always be an area with insufficient data. Due to the complexity of physical protection problems, information gained by exercising the evaluation models should be utilised in a supplementary way for aiding the safeguards analyst in his decision making process.
Claiborne, 1987[109]	USA	Intervention	Cost analysis	To undertake a cost analysis of the imposition of alternate (RG-17) safeguards approaches upon the nuclear power industry.	VAC recommendations can be implemented with less cost impact than the RG-17 criteria.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Davis, 1984[110]	UK	Intervention	Equipment evaluation: feasibility trial	To demonstrate that a laser reader can be used reliably inside a plutonium active glove box in conjunction with an automatic read-out balance interfaced to a microcomputer.	The criterion that labels be tamper-proof can be satisfied by the adoption of special paper and bank-note printing techniques together with adhesives which prevent the removal of the label without damage to the label itself.
Dean, 1982[111]	USA	Intervention	Discussion paper	Describes the development of the ROBIN (ROBot INspector) for facilities, both nuclear and non-nuclear, where it is desirable to minimise or eliminate inspector access to critical areas.	None for the NHS.
Delvin, 1990[112]	USA	Intervention	Discussion paper	Presents an interim report on an effort to develop a method that would provide a systematic and structured process for making evaluations of the 18 insider protection measures listed in the Site Safeguards and Security Plan Preparation Guide. To provide more uniform evaluations throughout the US Department of Energy community.	Three kinds of factors influence the effectiveness of insider protection programmes: 1. Factors associated with adversary acts against which the programmes provide protection 2. Factors associated with targets protected by the programmes and 3. Factors associated with use of the programmes.
Engi, 1980[113]	USA	Vulnerability assessment	Theoretical model	Describes the fundamental aspects of the Pathfinding Simulation (PATHS) procedure and instructs the user in the execution of PATHS on an interactive terminal.	PATHS obviates the need to identify and evaluate each and every complete potential route. As a result, the PATHS procedure permits facility analyses that would otherwise be beyond the capabilities of current generation computers.
Engi, 1977[114]	USA	Safety assessment	Theoretical model	To provide a structure for analysing the impact of guard tactics on the effectiveness of (nuclear) safeguards systems.	Not immediately relevant to NHS.
Engi, 1982[115]	USA	Safety assessment	Theoretical model	The Maintainability Analysis Procedure (MAP) was developed in order to model and analyse systems in which event sequences which included time-dependent phenomena and conditionally linked or characterised by arbitrary probability distributions are assumed to be significant.	Extension of MAP could be 1) improvement of the treatment of the statistical aspects of MAP, 2) a software interface for translating safety system fault trees into maintainability networks could be developed, and 3) a computer 'language' could be developed tailored to the use of MAP.
Ericson, 1980[116]	USA	Intervention	Theoretical evaluation	To examine nuclear power plant design changes for their impact on sabotage protection.	The authors believe the methodology can also be used to define systems which must be protected against accidents or which must be functional to counter the effects of accidents.
Ericson, 1981[117]	USA	Safety assessment	Discussion paper	To estimate the potential value of various configurations of plant design and damage control measures in providing protection against sabotage at commercial light water reactor (LWR) power plants and to establish the impact of such	None stated.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
				measures on facility costs, operations and safety. The programme emphasises new designs and future construction; therefore, design changes that might be retrofitted to existing plants or to plants under construction are not addressed.	
Foesch, 1994[118]	USA	Intervention	Discussion paper	To research commercially available systems that can be used in locating and tracking personnel and materials at DOE facilities.	Could apply to hospital security systems.
Gardner, 1993[119]	USA	Safety assessment	Discussion paper	To provide a standard set of assumptions, information sources and recommended computer codes to help with radiological sabotage analysis.	A standardised set of assumptions should be a valuable starting point for conducting this type of analysis. Standardisation of this process could potentially save scarce resources, aid in decision making and reduce risk of theft and diversion. The community should evaluate the impact of cleanup costs when conducting sabotage risk evaluations.
Grant, 1979[120]	USA	Safety assessment	Theoretical model	To describe the Sateguards Network Analysis Procedure (SNAP) network modelling technique and provide an example illustrating its use.	Only useful to the NHS if wanting to restrict entry to hospitals. 24 years old.
Grant, 1978[121]	USA	Safety assessment	Theoretical computer model	To describe the SNAP modeling technique and provide an example illustrating its use.	SNAP provides analysts with a tool for evaluating alternate safeguards systems designs and refining safeguards procedures at existing sites.
Hall, 1978[122]	USA	Safety assessment	Theoretical model	To describe the structure and use of ENUMPTH, a program for enumerating paths which an adversary might follow in attempting defeat of physical protection systems.	None stated. Employs card files and FORTRAN. Unlikely to be useful now.
Heyes, 1995[167]	UK	Safety assessment	Critical review/ discussion paper	To undertake a critical analysis of current techniques of probabilistic risk analysis (PRA) applied in the industry, with particular regard to the problems of quantifying risks arising from, or exacerbated by, human risk and/or human error.	The authors are doubtful that PRA is a methodologically sound form of analysis for the nuclear industry. The authors state that there is potential for manipulability and non-transparency in PRA studies and this may prove to be their biggest drawbacks.
Horton, 1985[123]	USA	Safety assessment	Theoretical model: probabilistic risk assessment	Presents a method for integrating probabilistic risk assessment (PRA) techniques into the assessment of the effectiveness of safeguards changes aimed at reducing the vulnerability of a nuclear power plant to sabotage. For any safeguards change that is considered, this integrated method will provide a measure of how the change affects the risk due to sabotage, tampering and vandalism and how the change affects risk due to operations.	Not stated.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Horton, 1995[124]	USA	Intervention	Equipment evaluation: experimental testing	To report an evaluation of seals used as tamper-indicating devices at Department of Energy (DOE) facilities.	The report makes recommendations for using currently available seals, and describes a new tamper-indicating technology.
Horton, 1993[125]	USA	Intervention	Equipment evaluation: experimental testing	To report an evaluation of seals used as tamper-indicating devices at Department of Energy (DOE) facilities.	The report makes recommendations for using currently available seals, and describes a new tamper-indicating technology.
Hulme, 1979[161]	USA	Safety assessment	Process evaluation/ theoretical model	To evaluate a new subroutine of SAFE called ADPATH.	Unclear if any implications for the NHS.
Hulme, 1986[126]	USA	Vulnerability assessment	Theoretical model	To present a network model which allows analysts to study the relative weaknesses in a (nuclear) facility safeguard system.	Only relevant if there are areas in a hospital that are high-security.
Hulme, 1980[127]	USA	Vulnerability assessment	Theoretical model	To present a computer program for safeguards analysis.	No implications (especially for the NHS) presented.
Jaeger, 1995[128]	USA	Intervention	Discussion paper	To demonstrate a site-independent system (Project Straight-Line) to monitor stored nuclear material and integrate the collection, processing and dissemination of information regarding this material.	None stated.
Johnston, 1995[129]	USA	Vulnerability assessment	Laboratory testing	As part of a comprehensive project on vulnerability assessment, 79 different passive tamper-indicating seals were examined.	The major finding of this work is disturbing: All the tamper-indicating seals examined can be defeated quickly, using low-tech methods available to almost anyone. For most of the attacks, minor modifications to the seal would substantially increase the difficulty of an attack. Most seals would also benefit significantly from changes in the manufacturer's suggested protocol for use and inspection. Very useful study.
Kennedy, 1977[130]	USA	Intervention	Speech about safeguards systems	To describe and examine the nature of the US safeguards systems. The article considers how the US is organised to develop and apply safeguards and some methods and techniques for assessing the effectiveness of safeguards systems. The means for bringing US knowledge to the attention of other nations that are similarly concerned is also discussed.	The effective deployment of safeguards systems requires that the work of ERDA and NRC be closely coordinated. A number of evaluation techniques are underway to produce more effective safeguards systems and these should be widely disseminated in the US and overseas.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Kjeldgaard, 1991[131]	USA	Vulnerability assessment	Theoretical model	To present that analytical methodology developed by the Sandia National Laboratories Production Risk Evaluation Program (PREP) which provides a logical method for identifying industrial sabotage targets from a system perspective.	A security strategy using graded protection based on a PREP analysis potentially could reduce security costs. PREP methods also provide quantitative insights to develop protection measures that do not infringe upon the liberties of personnel or complicate work practices.
Koski, 1998[132]	USA	Intervention	Discussion paper	To describe some proposed closure methods with shape memory alloys for radioactive material packages. These properties can be used to create a closure for radioactive materials packages that provides for easy robotic or manual operations and results in reproducible, tamper-proof seals.	Since closure rings are available from vendors in sizes up to 100mm diameter, the approach could be applied to a wide range of radioactive material packages.
Little, 1982[133]	USA	Intervention	Mathematical modelling	To apply Monte Carlo modelling of the neutronics of a lead slowing down time assay device	The results indicate that the useful range of the slowing down time assay device for homogeneous lead is a few tenths of an electron volt to >20keV.
Luna, 2000[166]	USA	Emergency planning	Simulation Computer models	A comparison of results from two spent fuel sabotage source term experiments (SNL and GRS).	The results of the SNL and GRS test programmes were consistent and provide a relatively straightforward empirical method to estimate respirable release from HEDD attacks on spent fuel casks.
Maimoni, 1978[134]	USA	Intervention	Literature review (non-systematic)	To review the current status of the Lawrence Livermore Laboratory (LLL) programme for Material Control and Accounting Systems assessment within the nuclear power industry. Purpose of the programme is to provide a means of testing compliance with improved regulations.	Potential material removal nodes could be made less vulnerable by the addition of check valves. Another way to reduce the plant vulnerability is to use materials that are intrinsically less desirable to an adversary.
Modarres, 2002[135]	USA	Safety assessment	Simulation: computer models	To examine risk assessment approaches to nuclear plant security assessment.	This systematic approach, when supplemented with the traditional defense-in-depth thinking, increased protection and security may be provided.
Moennich, 1978[136]	Germany	Safety assessment	Computer / theoretical modelling	To evaluate a domestic safeguards system providing adequate assurance against theft of special nuclear material (SNM) and sabotage by insiders designed for a reference Zero Power Plutonium Reactor (ZPPR) facility.	No implications are apparent.
Moormann, 1995[137]	Germany	Safety assessment	Research overview: laboratory and computer simulation	To present previously unpublished safety analyses of very severe HTR air ingress events with graphite oxidation as the main point of effort.	The author states that modelling of air flow into the core depending on leak conditions requires some additional examinations.
Moul, 1984[138]	USA	Intervention	Consensus guidelines	A study was performed by a team of analysts relative to licensing practices and the role of	Licensees should take steps to improve planning procedures, training, and organisational controls

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
				security as they relate to safeguards during safety-related emergencies (SREs).	necessary to assure an adequate security response during an SRE, and to assure that efforts are co-ordinated and integrated.
Musyck, 1981[164]	USA	Detection	Evaluation/ description of seals.	To evaluate and describe the manufacture of prototype seals following the channels of miniaturisation and cryptography. The study also looks at the possibilities of a third method using an auxiliary non-electronic seal.	Probably no implications for the NHS as the paper is more than 20 years old.
Myers, 1995[139]	USA	Intervention	Discussion paper	Describes the Mobile Detection, Assessment and Response Exterior System (MDARS-E)	Security system: probably of limited relevance to the NHS.
Parsons, 1977[140]	USA	Intervention	Theoretical computer model	To discuss the system design concepts of tamper and radiation resistant instrumentation, including a brief description of the tamper and radiation resistant features, the preliminary test results, and the significance of the work.	This technique provides the safeguards inspector and the industry with a new approach for obtaining accountability data without loss in accuracy.
Paulus, 1994[141]	USA	Safety assessment	Theoretical models	To present two complementary analysis tools: ASSESS (Analytic System and Software for Evaluation of Safeguards and Security) and SEES (Security Exercise Evaluation Simulation)	Using both programs together, vulnerability analyses achieve both breadth and depth.
Paulus, 1988[142]	USA	Vulnerability assessment	Theoretical model	To discuss the BATLE computer program which carries out vulnerability analysis of security forces stopping or preventing theft or sabotage of special nuclear material at a nuclear site.	This tool will allow analysts to gain useful insights into the neutralisation aspect of site security with a modest outlay of time for problem preparation and calculations.
Paulus, 1993[143]	USA	Vulnerability assessment	Theoretical model	To analyse the vulnerability of nuclear materials to theft or sabotage using two different computer programs.	Using both programs together, vulnerability analyses achieve both breadth and depth.
Richter, 1991[144]	Luxem-bourg	Intervention	Equipment evaluation: Field tests	To prove the functional performance and reliability of the tamper-resistant TV link (TRTL) under real facility conditions, to collect practical experience in a plant with regard to the appropriateness of the system design and to enhance the system performance by introducing improvements on the basis of the test results.	No implications for the NHS.
Rountree, 1983[145]	USA	Intervention	Theoretical model	The SECURity Officer Response Strategies (SECURORS) technique is applied to a nine-level generic nuclear power plant to determine security officer deployment locations within the facility subsequent to detection of adversary intrusion.	Since the SECURORS method utilises information from the SAFE methodology it is recommended that a SECURORS analysis be conducted in conjunction with a SAFE analysis.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Rountree, 1983[146]	USA	Intervention	Theoretical model	Addresses the problem of protecting a large number of nuclear power plant areas by a limited security resource.	Not clear. Only a short conference abstract.
Rowland, 1983[147]	USA	Intervention	Theoretical computer model	To develop the TASK computer model, to provide an optimal Target Assignment for Security officers to K targets.	The aggregate target strategy enables the TASK model to assign limited numbers of security officers for a much improved system protection.
Russell, 1979[168]	USA	Safety assessment	Database analysis	An assessment of the nature and likelihood of attempts at industrial sabotage and theft of nuclear fuel directed against a hypothetical US nuclear power station, and the methodology used to quantify the outcome (probability of success).	Details of the calculational methods, key assumptions, and important sensitivities to engagement outcome are yet to be presented.
Sabuda, 1982[148]	USA	Safety assessment	Theoretical model	Provides detailed application information concerning the SNAP Operating System as well as a detailed discussion of all SOS components and their associated command input formats.	None.
Schechter, 1979[149]	USA	Prevalence (extent of problem)	Synopsis of nine interviews	A series of nine interviews was conducted with recognised experts in the field of institutional internal security, for the purpose of gaining insight into the insider threat to nuclear facilities.	The interviews provided a number of useful insights for evaluating the insider threat to nuclear safeguards. It appears that an effective set of personnel policies, as well as a strong programme of internal controls, are necessary for minimising this threat.
Scott, 1983[150]	USA	Safety assessment	Field equipment evaluation	To describe some of the elements that have been installed as safeguard systems and the field tests that have been performed at an operating nuclear reactor facility.	The results of the elements tested in this study indicate that such devices are viable candidates for inclusion in systems designed to protect against insider sabotage activities.
Sheldon, 1985[151]	USA	Detection	Mathematical analyses	To investigate the effect of fixture set-ups on the correlations for intact tamper-proof seals on underwater nuclear fuel assemblies.	The authors conclude that set-up errors increase the variability of r, and increase the standard deviation.
Sliva, 1996[160]	USA	Detection	Discussion/ overview	To find more cost-effective methods of securing nuclear materials or related items of high value in storage or transport.	These methods have implications for the nuclear waste industry and are designed to sense movement or tampering of materials contained in the storage units being investigated. The relevance to the NHS is unclear.
Strait, 1986[152]	USA	Safety assessment	Workshop on theoretical model	To present the Safeguards Evaluation Method - Insider Threat - a field-applicable tool to evaluate facility safeguards against theft or diversion of special nuclear material (SNM) by non-violent insiders.	None for the NHS.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Tabatabai, 1986[153]	USA	Vulnerability assessment	Theoretical model	A study to evaluate alternatives to the design and operation of nuclear power plants, emphasing a reduction of their vulnerability to sabotage.	To deal with the threat of insider sabotage, 1) vulnerability should be reduced through increased operating flexibility and surveillance, 2) address staff qualifications and 3) access to sensitive areas.
Vannoni, 1988[163]	USA	Safety assessment	Theoretical model	To evaluate the Sandia National Laboratories' Production Risk Evaluation Program (PREP) which provides a logical method for identifying industrial sabotage targets from a system perspective.	Unclear if any implications for the NHS.
Varnado, 1978[154]	USA	Vulnerability assessment	Theoretical model: fault tree analysis.	To discuss the use of fault tree analysis techniques to systematically identify: 1. The sabotage events which can lead to release of significant quantities of radioactive materials, 2. The areas of the plant in which the sabotage events can be accomplished, and 3. The areas of the plant which must be protected to assure that release does not occur.	None presented. Not a full paper, just a long introduction.
Varnado, 1981[155]	USA	Vulnerability assessment	Theoretical model	To provide an extensive set of modular logic for various types of nuclear power plant systems including fluid systems, reactivity control systems, electric power systems, control circuits, actuation systems and ventilation systems.	The procedures outlined here can significantly reduce some of the major disadvantages of traditional fault tree analysis methods. Unclear if this article relates to sabotage or tampering.
Varnado, 1978[156]	USA	Vulnerability assessment	Theoretical / mathematical model	To discuss the use of fault tree analysis to identify those areas of nuclear fuel cycle facilities which must be protected to prevent acts of sabotage that could lead to significant release of radioactive material.	Vital area assessment provides a disciplined, logical, repeatable method for determining vital areas in nuclear facilities. There are generic sabotage fault trees which make it possible for an analyst with a minimum knowledge of fault tree analysis techniques to develop detailed fault trees for specific power reactor plants.
Wilkey, 1995[157]	USA	Vulnerability assessment	Theoretical model	To develop a standard guide for performing vulnerability assessments.	Development of an ASTM standard practice for performing vulnerability assessments will provide improved consistency in the vulnerability assessment process and may decrease the cost and effort required for validation.
Winblad, 1987[158]	USA	Safety assessment	Theoretical computer model	To present the assessment model 'Systematic Analysis of Vulnerability to Intrusion (SAVI)', a PC-based path analysis model.	SAVI provides help for the analyst in considering possible upgrades to the most vulnerable paths.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Winblad, 1989[159]	USA	Safety assessment	Theoretical model	To present the ASSESS (Analytic System and Software for Evaluating Safeguards and Security) Outsider Analysis module.	Outsider is the ASSESS module responsible for determining the vulnerability of a facility to potential violent intrusion by outside threats. Outsider has faster algorithms, better threat and deceit modelling, accepts larger ASDs and generates more detailed results than SAVI.
Wright, 1995[70]	USA	Intervention	Equipment evaluation: pre and post-test	To evaluate numerous prototype tamper tapes adhered to different surfaces under environmental. aging conditions. Exposed tamper tapes were visually inspected & evaluated for tamper resistance to determine the effects of the weathering conditions.	The overall results of the rapid-set adhesive weathering studies indicated that the epoxy 2 adhesive weathered better than the other adhesives on tamper tapes prepared with any of the Confirm materials.

Sabotage of nuclear transportation (NUT)

Eight studies or articles were identified that fitted into the 'NUT' category.[170-177] All of the studies reported simulations of sabotage/attack on either the transportation of nuclear materials or the containers in which such materials were transported. Some also reported the effects of such attacks on urban or densely populated areas.

Table 42: Summary table methods (NUT)

Methods	Emergency planning	Safety assessment	Risk assessment	Intervention
Number of studies	4	1	2	1

All but one of the studies were carried out in the USA[170-174, 176, 177] and the other was carried out in the UK.[175] The studies were published during the years 1977-1990. More recent reports were not identified which may suggest increased security and a reluctance to publish security evaluation results.

Table 43: Summary table place of study

Country	USA	UK
Number of studies	7	1

Table 44: Summary table of year of publication

Date of publication	Not later than 1980	1981-1985	1986-1990	1991-1995	1996-2000	2001 and later
Number of studies	1	4	3	0	0	0

Six studies were theoretical modelling applications,[170,172-175,177] one was a critical appraisal of a previously implemented theoretical model[176] and one was a discussion of a previous safety assessment model.[171] The aim of all of the studies was to predict outcomes of sabotage attacks on nuclear materials or the containers for such materials being transported through densely populated areas. The studies all reported specific and similar guidance in order to limit the effects of any nuclear materials released in urban areas e.g., time of day, routes chosen, and protection of crew members. None of these studies appear to have directly relevant implications for the NHS.

Table 45: Summary table included studies (NUT)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Brown, 1985[175]	UK	Emergency planning	Theoretical model	A theoretical study of the events following a hypothetical criticality accident to a particular simplified notional design of transport flask. Possible causes of the accident are sabotage, quality assurance failure or accidental very severe impact causing rearrangement of flask components. To examine the situation when criticality occurs during a refill of a PWR flask.	None stated.
Resnikoff, 1990[176]	USA	Risk assessment	Critical appraisal of a theoretical model.	To critically review the RADTRAN computer model, used to estimate the risks of transporting waste to a high-level repository.	The authors conclude that the RADTRAN model underestimates the health impacts of transporting high-level waste to the proposed Yucca mountains repository and suggest improvements to the model.
Sandoval, 1984[170]	USA	Emergency planning	Theoretical model with preliminary experiments (discussion of)	To provide experimental data characterising the quantity, physical, and chemical form of fuel released from hypothetical attacks on spent fuel shipping casks. The objectives were limited to: a) evaluating the effectiveness of selected high explosive devices (HED) in breaching full-size spent fuel casks; b) quantifying and characterising relevant aerosol properties of the released fuel; and c) using the resulting experimental data to evaluate the radiological health consequences resulting from a hypothetical sabotage attack on a spent fuel shipping cask in a densely populated area.	This work could be the basis of additional regulatory revisions of the NRC physical protection requirements. In a larger sense, this work can also be the basis of more credible worst-case analyses since it defines the actual result of an event that is well beyond any expectations of cask failures in accident environments.
Sandoval, 1981[171]	USA	Safety assessment	Discussion paper	To evaluate the radiological consequences resulting from the transportation of radioactive materials in urban areas for various types of transportation scenarios, including sabotage.	This paper lists ongoing data gathered in order to support more informed risk assessments in the transportation of spent nuclear fuels.
Sandoval, 1982[172]	USA	Emergency planning	Theoretical model: estimates based on modelling and preliminary experiments	To generate a preliminary estimate of the health effects and/or consequences resulting from sabotage of spent (nuclear) fuel truck shipments, and to determine experimentally the quantity, size and chemical form of any released material.	Unclear.

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Sandoval, 1986[173]	USA	Intervention	Theoretical model	Evaluating the effectiveness of selected high energy devices (HED) in breaching full scale spent fuel casks, quantifying & characterising relevant aerosol & radiological properties of the released radionuclides & using the resulting experimental data to evaluate the radiological health effects resulting from a hypothetical attack on a spent fuel shipping cask in a densely populated urban area.	The work could be the basis of credible 'worst case' analyses since it defines the results of an event which is well beyond any cask failure scenarios postulated for severe accident environments.
Sandoval, 1987[177]	USA	Emergency planning	Theoretical model: using an experimental database	To estimate the consequences of a hypothetical sabotage attack on a spent fuel shipping cask. Primary objectives were limited to: evaluating effectiveness of selected high energy devices (HED) in breaching full scale spent fuel casks; quantifying and characterising relevant aerosol and radiological properties of the released radionuclides; using the resulting experimental data to evaluate the radiological health effects resulting from a hypothetical attack on a spent fuel shipping cask in a densely populated urban area.	This work could be the basis of credible 'worst case' analyses since it defines the results of an event which is well beyond any cask failure scenarios postulated for severe accident environments.
Taylor, 1977[174]	USA	Risk assessment	Theoretical model	To predict the radiological consequences of transportation of radioactive material in an urban environment.	None reported, other than those in the results section.

Tampering with research (RES)

One study was identified that fitted into the 'RES' category.[178] The included study was a review, published in 2002, which discussed the key concepts in defending against deciphering of allocation concealment in randomised trials. Where the review was conducted was unclear. The review presented the proper approaches to allocation concealment in randomised trials and also gave many examples of improper allocation concealment and how they could be detected. The information in this article is of importance to researchers but is not directly applicable to sabotage or tampering in the NHS.

Table 46: Summary table included studies (RES)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Schulz, 2002[178]	Unclear	Other	Discussion paper	To discuss key concepts in defending against deciphering of allocation concealment in randomised trials.	Minimum and expanded criteria for adequate allocation concealment schemes: Sequentially numbered, opaque, sealed envelopes. Envelopes are opened sequentially only after participant details are written on the envelope. Pressure-sensitive or carbon paper inside the envelope transfers that information to the assignment card (creates an audit trail). Cardboard or aluminium foil inside the envelope renders the envelope impermeable to intense light. Sequentially numbered containers. All of the containers were tamperproof, equal in weight and similar in appearance. Pharmacy controlled. Indications that the researchers developed, or at least validated, a proper randomisation scheme for the pharmacy. Indications that the researchers instructed the pharmacy in proper allocation concealment. Central randomisation. The mechanism for contact (telephone, fax or email), the stringent procedures to ensure enrolment before randomisation and the thorough training for those individuals staffing the central randomisation office.

Self-sabotaging behaviour/psychological factors (PSY)

Five studies were identified that fitted into the category 'PSY'.[179-183] Three focussed on identifying the extent of the self-sabotaging behaviour problem: two of these were surveys[179,180] and one was a retrospective record review.[182] The other two studies were descriptive, one used interviews[181] and the technique used by the other was unclear.[183] Two of the five studies were published in the USA and the country of publication of the other three studies was unclear. One study was published in 1976[179] and the other four were published in 1998 or later.

None of the studies were particularly relevant to sabotage or tampering within the context of the NHS. One study focussed on the avoidance of self-disclosure in psychotherapy sessions, one examined the association between sexual orientation and health risk behaviours in adolescents, one was about women and anger expression, one defined the characteristics of a population of adolescent females with disturbed behaviour, and one was about the psychological profile of Underwater Sabotage Device Disposal operators in the South African Navy. There were no implications for the NHS with regard to patient safety.

Table 47: Summary table included studies (PSY)

Study details	Country	Focus of research	Type of study or article	Aims/ Objectives	Implications
Anchor, 1976[179]	Unclear	Prevalence (extent of problem)	Survey	To determine the extent to which avoidance of self-disclosure was as characteristic of the middle sessions of psychotherapy as it is of the initial sessions.	The position that there are ways in which psychotherapy sabotage can be reduced was discussed. Not relevant.
Garofalo, 1998[180]	USA	Prevalence (extent of problem)	Cross-sectional survey	To examine the association between sexual orientation and health risk behaviours among a representative, school-based sample of adolescents.	These findings suggest that educational efforts, prevention programmes and health services must be designed to address the unique needs of gay, lesbian or bisexual youth.
Jack, 2001[181]	USA	Qualitative descriptive	Interview	To discover what elements of anger expression women identify as most important in their experience.	None for this review. Study is of questionable relevance.
Jasper, 1998[182]	Unclear	Prevalence (extent of problem)	Retrospective record review	To describe the characteristics of a population of adolescent females who demonstrated disturbed behaviour so that testable hypotheses for future research could be generated. To examine whether the prejudices held by professionals working with females stood up to closer examination.	None. Not relevant.
van Wijk, 2001[183]	Unclear	Descriptive	Description of psychological traits	1. To determine the extent to which psychological instruments could be used to describe the psychological profile of Underwater Sabotage Device Disposal (USDD) operators in the South African Navy. The Advanced Progressive Matrices, 16-Personality Factor Questionnaire (16PF), Self-Directed Search Questionnaire and Rey Complex Figure Test were used. 2. To determine the extent to which the 16PF could differentiate between USDD operators and other clearance divers.	Unclear as to implications. Not relevant.

Discussion

Summary of results

Although a large number of articles were identified in the searches, a much smaller number were actually included in the review (180 out of 6846). Many of the citations identified were not relevant, or appeared not to be based on any research. Those articles that were relevant covered various aspects of sabotage or tampering, including the extent of the problem, identification of the factors that may cause or foster sabotage or tampering, together with discussion papers and reports of actual interventions to prevent or detect sabotage or tampering. The settings also varied, with some articles originating from clinical practice, some from the food industry and some from nuclear sites. Most of the studies were conducted in the USA and only eleven were carried out in the UK. The issues for consideration and possible implications for the NHS, arising from the set of studies included in this review, are set out in the following section.

Tampering with equipment or drugs or clinical practice

When patient-controlled analgesic devices or home ventilator devices are used ongoing education and support for patients and caregivers needs to be provided. Most patient-controlled analgesic devices are fitted with alarm systems to prevent tampering. The tamper-evident tape described in one study, could be used to seal packets of equipment that need to be protected from tampering. A series of uncontrolled experiments to evaluate the utility of various forms of tamper-evident packaging may have implications for the NHS in terms of tamper-evident packaging for medical equipment and drugs. Two case-control studies identified the theft of narcotics by hospital staff as a potential danger to patients. Measures to prevent tampering or theft and to deal with any resulting adverse events should be in place

There are possible implications for the NHS arising from two studies of the preparation of drug solutions, although both provide information more relevant to general patient safety than to sabotage or tampering. The older study found that preparing drug solutions centrally in a disposable, tamper-proof, unit-of-use package, rather than having staff prepare solutions on the ward, reduced medication errors. The later study found that preparing standard, as opposed to varied, concentrations of intravenous solutions led to increased accuracy. The findings of one study in clinical prcatice may have implications for the NHS where a patient died and it was suspected that this was due to a malicious act. The study focussed on the accurate detection of digoxin intoxication from post-mortem examination, by measurement of digoxin-like immunoreactive substances (DLIS).

Tampering with patient records

The potential for watermarking patient records (either paper or electronic) to prevent or detect tampering could be considered.

Organisational factors associated with sabotage or tampering

The available literature suggests one possible cause of sabotage or tampering may be due to frustration and feelings of inequity in the workplace (perceived or otherwise). Management intervention to handle worker conflict, reduce tension-causing situations and promote security awareness was advocated.

Tampering with food/water systems

One study with potential relevance to the NHS was a risk assessment study of the potential threat of tampering with water systems, in which areas of vulnerability were identified. Similar assessments of NHS hospitals could be made to identify areas of vulnerability. The other studies did not have direct implications for the NHS but perhaps some of the techniques outlined could be considered if tampering with drugs or hospital food products was suspected.

Sabotage at nuclear sites

None of the studies were directly applicable to the NHS, although some of the modelling techniques could be adapted to investigate insider threats of sabotage within NHS facilities. Several of the findings with regard to issues of vandalism, theft etc, could also be applied to situations within the NHS.

Overall, the areas which appeared to have the most direct application to the NHS were the use of alarms to prevent tampering with equipment or drugs, the use of packaging to prevent and detect tampering and the procedures which should be taken if tampering is suspected. A research agenda that includes these areas could be considered.

Limitations of the review

In considering the above implications a number of limitations of the review must also be noted.

Literature searching

The search was very focused in terms of the search words employed (see Appendix A) but quite broad in terms of the range of databases that were searched. The databases searched hold, in the main, records of research articles. However, due to the limited research base on the topic of sabotage or tampering future investigation would benefit from searching other sources for information such as formal law reports, findings of conduct hearings of regulatory bodies, records of the coronial system, alert letters and findings of inquiry reports. Some details are given below. In addition, further searches might benefit from extending the number of search terms.

Law reports and case digests: there are a number of electronic sources (available on subscription) that can be used to identify relevant law reports and case digests. The two main sources are Westlaw UK (produced by Sweet and Maxwell) and Butterworths Lexis that cover primary sources such as legislation, statutory instruments, cases, Law Reports, treaties etc and secondary sources such as journal articles. Further details of these two databases and other sources that cover law reports are available in Appendix E.

Regulatory bodies and alert letters: most UK government regulatory bodies have a website which can be searched (e.g. Medicines and Healthcare Products Regulatory Agency (http://www.mhra.gov.uk)). The MHRA website contains MDA safety warnings including device alerts, device bulletins, hazard notices, medical device alerts and safety notices.

Coronial system: reports from coroners courts and inquests are not generally available for public viewing. It is possible however to request the Notes of Evidence from an inquest if the details of the deceased and an approximate date of death are known. Enquirers must also know which coroners office to contact. A list of coroners is available at http://www.infolaw.co.uk/directory/coroners.htm. The record could be a transcript from a tape-recording or the coroner's own notes, which may not be a full verbatim record. Archival material is held by the appropriate local government archive service.

Inquiry reports: these can be identified from a number of sources including the SIGLE (System for Information on Grey Literature in Europe) database, which has details of grey or semi-published literature, for example, technical or research reports, dissertations, conference papers and preprints, some official publications, together with discussion and policy papers. Other sources are the British Library's public catalogue (http://blpc.bl.uk) and the Department of Health's POINT database (http://www.info.doh.gov.uk/doh/point.nsf).

The Management literature may also be of interest, as it may offer additional insights into the causes of sabotage or tampering and approaches to its management. Useful places to investigate include ABI/Inform, Management Contents, Harvard Business Review and Business and Management Practices.

Assessment of included studies

It must be borne in mind that this was a scoping review, rather than a full systematic review, the aim of which was to map the literature relating to sabotage or tampering. All identified records were categorised based on titles and abstracts and full papers were ordered for those records categorised as research papers. Limited information was recorded about each paper including the type of article, the focus of the research, the objectives, the methods used, the results (if any) and any reported implications (see Appendix B). The reviewers then assessed which of these implications might be of relevance to the NHS. No assessment was made of the methodological quality of the included studies. Assessment of the relevance and importance of any implications arising from the studies

was based on the type of study and on its context and this should be borne in mind when reading the findings of this scoping review.

Implications for the NHS

Currently there appears to be no reliable way in which information about possible or actual sabotage or tampering in the NHS is captured and shared. The development of effective procedures for the prevention or detection of this problem will be aided by accurate and thorough reporting when it is suspected. This information could also be used to assess the effects of any measures implemented to try and prevent sabotage or tampering. Accurate reporting will require the use of standard terms.

Across the literature examined in this scoping review the terms ‘sabotage’ and ‘tampering’ were used inconsistently. For example, many of the included studies reported non-malicious tampering (without intent to injure), such as tampering by a relative with a patient’s ventilator (perhaps with the intention of improving its action), or tampering by a patient with their own patient-controlled analgesic device. In two studies where patients in an intensive care unit were adversely affected by staff tampering with their opiate supply, the intention of the perpetrators was not to injure the patients, but to steal the drugs and cover up the theft. Perhaps non-malicious tampering, could also be described as wilful negligence. The Oxford English Dictionary describes sabotage as ‘disabling damage deliberately inflicted… to ruin, destroy or disable deliberately and maliciously (frequently by indirect means)’ and ‘tamper’ as ‘to have to do or interfere with improperly, to meddle with (a thing)…. to meddle with medically…. to meddle or interfere with (a thing) so as to misuse, alter, corrupt or pervert it’. Thus, sabotage may be used to refer to deliberate and malicious destruction, and tampering to refer to any procedure that causes damage or has adverse consequences, whether the procedure was deliberate or malicious or otherwise.

If the aim is to implement procedures for the detection of sabotage or tampering in the NHS, it may be less important whether the damage is malicious and deliberate or non-malicious and unintended, as the end result (the damage) is the same. However, if the aim is to prevent sabotage or tampering, then malicious and non-malicious damage needs to be determined as the causes and factors leading to the damage are likely to be very different. There may be further useful discussion about this issue in the management and organisational literature.

Conclusions

Overall, the research literature relevant to sabotage or tampering is very limited, and the available research has few implications for the NHS. The issues considered to be of most relevance, and with potential for further action are summarised below.

- Consideration of systems and procedures for the accurate and thorough reporting of sabotage or tampering when it is suspected.

- Consideration of the use of alarms or packaging to prevent tampering with equipment or drugs.

- Consideration of the use of packaging to detect tampering with equipment or drugs.

- Consideration of a future research agenda which could usefully investigate the prevalence of sabotage or tampering across the NHS; the factors that lead to sabotage or tampering, together with the evaluation of interventions to prevent, detect or reduce sabotage or tampering.

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Appendix A: Searches

1. Databases

1a. MEDLINE. Ovid web interface, searched 6/12/02

1 (sabotage or tamper or tampering or tampered or deliberate damage).ti,ab. (244)
2 animal/ not (human/ and animal/) (2607560)
3 (deliberately adj3 damage$).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading] (16)
4 security measures/ (2911)
5 or/1,3 (260)
6 5 not 2 (229)

229 records were identified. Following the identification of further potential keywords a second search was conducted on 4/3/03 using the same interface. The original results were excluded from the new search:

1 (sabotage or tamper or tampering or tampered or deliberate damage).ti,ab. (261)
2 (deliberately adj damage$).mp. (8)
3 (deliberately adj3 damage$).mp. (16)
4 or/1,3 (277)
5 animal/ not (human/ and animal/) (2640973)
6 4 not 5 (245)
7 (malevolent or malevolence or malice or malicious).ti,ab. (187)
8 (adulteration or adulterate).ti,ab. (291)
9 (antitamper$ or anti-tamper$).ti,ab. (2)
10 or/7-9 (479)
11 10 not 5 (381)
12 11 not 6 (376)
13 sabotaging.ti,ab. (15)
14 13 not 6 (11)
15 12 or 14 (387)

387 records were identified.

1b. EMBASE. Ovid web interface, searched 6/12/02

1 (sabotage or tamper or tampering or tampered or deliberate damage).ti,ab. (184)
2 animal/ not (human/ and animal/) (12642)
3 1 not 2 (184)
4 (deliberately adj3 damage$).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name] (8)
5 1 or 4 (192)
6 5 not 2 (192)

192 records were identified.

1c PsycINFO. WebSPIRS interface, searched 6/12/02

#1 sabotage or tamper or tampering or tampered(220 records)
#2 deliberate damage(0 records)
#3 deliberately near damage*(15 records)
#4 (deliberately near damage*) or (deliberate damage) or (sabotage or tamper or tampering or tampered)(235 records)

235 records were identified.

1d. CINAHL Ovid web interface, searched 6/12/02

1 (sabotage or tamper or tampering or tampered or deliberate damage).ti,ab. (57)
2 animal/ not (human/ and animal/) (308)
3 1 not 2 (57)
4 (deliberately adj3 damage$).mp. [mp=title, cinahl subject heading, abstract, instrumentation] (1)
5 (1 or 4) not 2 (58)
6 crime/ and drugs/ and safety/ (1)
7 crime/ and drug labelling/ (0)
8 crime/ and "equipment and supplies"/ (4)
9 materials management/ and crime/ (0)
10 or/6-9 (5)
11 5 or 10 (62)

62 records were identified.

1e. Cochrane Library 2002/4. Searched 6/12/02

(((SABOTAGE or TAMPER) or TAMPERING) or TAMPERED)
(DELIBERATE* near DAMAGE*)
(DELIBERATE* near DAMAGE)
(DELIBERATE next DAMAGE)
SECURITY-MEASURES*:ME
(DRUG-PACKAGING:ME and CRIME:ME)
(((((#1 or #2) or #3) or #4) or #5) or #6)

1f. Science Citation Index, Searched on Datastar service, 6/12/02

1. SABOTAGE OR TAMPERING OR TAMPER OR TAMPERED
2. DELIBERATE ADJ DAMAGE$
3. DELIBERATE ADJ DAMAGE
4. DELIBERATELY ADJ DAMAGED
5. 1 3 4
6. DRUG OR DRUGS OR HEALTH OR MEDICINE$ OR EQUIPMENT OR MACHINE$ OR BOTTLES
7. VEHICLE$ OR TRAIN OR TRANSPORT OR PLANE$ OR AIRPLANE$ OR FLIGHT OR AIRLINE$ OR BAGGAGE OR BOATS OR BOAT OR SHIPPING
8. FOOD OR FOODS OR MANUFACTURING
9. and (6 or 7 or 8)

162 records were identified

1g. Foodline, Searched on Datastar service, 6/12/02

Search terms:

SABOTAGE OR TAMPERING OR TAMPER OR TAMPERED

Following the identification of further potential keywords, a second search was conducted on 4/3/03 using the same interface. The original results were excluded from the new search:

1 SABOTAGE OR TAMPERING OR TAMPER OR TAMPERED
2 SABOTAGING OR MALEVOLENT OR MALEVOLENCE OR MALICE OR MALICIOUS OR DELIBERATE(W)ADULTERATION OR ANTITAMPER$
3 2 NOT 1

1h. Foods Adlibra, Searched on Dialog service, 6/12/02

S1 395 SABOTAGE OR TAMPER OR TAMPERING OR TAMPERED

This was used to indicate the volume of research and no results were downloaded.

1i Food Science and Technology Abstracts, Searched on Datastar service, 6/12/02

1 SABOTAGE OR TAMPERING OR TAMPER OR TAMPERED
2 DELIBERATE ADJ DAMAGE$
3 DELIBERATE ADJ DAMAGE
4 DELIBERATELY ADJ DAMAGED
5 1 3 4

245 records were retrieved.

1j TRIS, Searched on the Dialog service, 6/12/02

SABOTAGE OR TAMPER OR TAMPERING OR TAMPERED

226 records were retrieved. Following the identification of further potential keywords, a second search was conducted on 4/3/03 using the same interface. The original results were excluded from the new search:

SABOTAGE OR TAMPER OR TAMPERING OR TAMPERED
SABOTAGING OR MALEVOLENT OR MALEVOLENCE OR MALICE OR
MALICIOUS OR DELIBERATE(W)ADULTERATION OR ANTITAMPER?
S2 NOT S1

19 records were retrieved.

1k. Energy Scitech, Searched on the Dialog service, 6/12/02

s (SABOTAGE OR TAMPER OR TAMPERING OR TAMPERED OR DELIBERATE(W)DAMAGE)/TI

1l. PREMEDLINE. Ovid web interface, searched 6/12/02

1 (sabotage or tamper or tampering or tampered or deliberate damage).ti,ab. (13)
2 [animal/ not (human/ and animal/)] (0)

3 1 not 2 (13)
4 (deliberately adj3 damage$).mp. [mp=title, abstract] (0)

13 records were retrieved

1m. National Research Register, 2002/3. Searched 9/12/02

1 (((SABOTAGE or TAMPER) or TAMPERING) or TAMPERED)
2 (DELIBERATE* near DAMAGE*)
3 (DELIBERATE* near DAMAGE)
4 (DELIBERATE next DAMAGE)
5 SECURITY-MEASURES*:ME
6 (DRUG-PACKAGING:ME and CRIME:ME)
7 (((((#1 or #2) or #3) or #4) or #5) or #6)

The only results were about security measures in psychiatric hospitals.

1n. SIGLE, searched via the ARC WinSPIRS service, 6/12/02

1 sabotage or tampering or tampered or tamper
2 deliberate* near damage*

7 records were retrieved.

1o HMIC, searched via the ARC WinSPIRS service, 6/12/02

1 sabotage or tampering or tampered or tamper
2 deliberate* near damage*

13 records were retrieved.

1p Inspec searched via the WebSPIRS service, 3/3/03

#1 sabotage or tamper or tampered or tampering or deliberate damage or deliberately damaged(1043 records)
#2 (explode "authorisation-" in DE) or (explode "computer-crime" in DE) or (explode "computer-viruses" in DE) or (explode "cryptography-+" in DE) or (explode "message-authentication" in DE) or (explode "security-of-data" in DE)(37032 records)
#3 #1 not #2(533 records)

533 records were retrieved.

1q NTIS (National Technical information Service) searched via Datastar, 3/3/03

1 tamper or tampering or tampered
2 sabotage
3 deliberate adj damage
4 deliberately adj damaged
5 1 2 3 4

942 records were retrieved.

1r EI Compendex searched via Datastar, 3/3/03

1_: tamper or tampering or tampered
2_: sabotage
3_: deliberate adj damage
4_: deliberately adj damaged
5_: 1 2 3 4

729 records were retrieved.

1s Graylit web site, http://graylit.osti.gov/, 4/3/03

This site searches the (US) Defense Technical Information Center report collection, the (US) Department of Energy Information Bridge Report Collection, The (US) EPA National Environmental Publications Internet site, and the NASA Propulsion Lab report collection.

The following search terms were used:

Sabotage or tamper*

313 references were saved as a web page.

1t The Harvard Business Review database (08/90-FEB'03) was searched on the 24/3/03 using the Datastar service.

Search strategy:

(sabotage or tampering or sabotaging or deliberate adj damage).ti.
deliberately adj damage$.ti.
(malice or malicious or malevolent).ti.
1 or 2 or 3
4.ab.
(sabotage or tampering or sabotaging or deliberate adj damage)
deliberately adj damage$
(malice or malicious or malevolent)
6 7 8

When the search of words in titles produced 0 records the results of the search in all fields were selected and printed out (52 titles).

1u ABI/INFORM ('71 TO DATE) was searched on the 24/3/03 using the Datastar service.

Search strategy:

(SABOTAGE OR TAMPERING OR SABOTAGING OR DELIBERATE ADJ DAMAGE).TI.
DELIBERATELY ADJ DAMAGE$.TI.
(MALICE OR MALICIOUS OR MALEVOLENT).TI.
1 OR 2 OR 3

204 records were printed out.

1v MANAGEMENT CONTENTS ('86-TO DATE) was searched on the 24/3/03 using the Datastar service.

(SABOTAGE OR TAMPERING OR SABOTAGING OR DELIBERATE ADJ DAMAGE).TI.
DELIBERATELY ADJ DAMAGE$.TI.
(MALICE OR MALICIOUS OR MALEVOLENT).TI.
1 OR 2 OR 3

16 records were printed out.

1w Management and Marketing Abstracts ('75- to date) was searched on the 24/3/03 using the Datastar service.

(SABOTAGE OR TAMPERING OR SABOTAGING OR DELIBERATE ADJ DAMAGE).TI.
DELIBERATELY ADJ DAMAGE$.TI.
(MALICE OR MALICIOUS OR MALEVOLENT).TI.
1 OR 2 OR 3

10 records were printed out.

1x BUSINESS A.R.T.S ('76 TO DATE) was searched on the 24/3/03 using the Datastar service.

(SABOTAGE OR TAMPERING OR SABOTAGING OR DELIBERATE ADJ DAMAGE).TI.
DELIBERATELY ADJ DAMAGE$.TI.
(MALICE OR MALICIOUS OR MALEVOLENT).TI.
1 OR 2 OR 3

591 records were downloaded.

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2. Web sites

2a The Civil Aviation Authority web site, http://www.caa.co.uk/default.asp, 4/3/03

The following search terms were used:

Sabotage tamper*

10 documents were identified and scanned.

2b The Federal Aviation Authority web site, http://www1.faa.gov/, was searched on 17/3/03

The FAA search engine (DOTBOT) was used and the term ‘sabotage’ was entered. ‘Sabotage’ produced 125 records, of which the first 100 were scanned. Using the same DOTBOT search engine further searches, using ‘tampering’ and ‘sabotage’ (separately) were conducted on Transportation

Security Administration documents. Zero records were identified from ‘sabotage’ and 6 records from ‘tampering.’

2c The Internation Atomic Energy Authority’s WorldAtom site was searched on the 17/3/03. http://www.iaea.or.at/worldatom/

Searching the site’s search engine using ‘sabotage’ produced 134 records. The listing was printed and scanned for relevant items.

2d Google was searched on the 17/3/03. http://www.google.co.uk

Google was searched using the string ‘+preventing +sabotage’. Many tens of thousands of records were returned and the first 100 records were scanned. The most relevant documents were downloaded, in particular the Employee Sabotage web site and MIPT.

Appendix B: Data extraction tables

TOPIC: EQUIPMENT

Study details	Anonymous, 2001[1]
Country of publication	USA
Topic category	EQI
Focus of research	Intervention
Type of study or article	Testing equipment
Aims/ Objectives	To evaluate nine patient-controlled analgesic (PCA) pumps from six suppliers.
Description of study and methods	Nine PCA pumps from six suppliers were evaluated. Three of the pumps were syringe-type, while the others used cassette-based fluid delivery. The accident resistance of each device was also tested. The evaluation criteria and test methods were based on information obtained from a number of sources, along with comments from external clinical reviewers and the experience and judgment of clinical and technical staff. Testing was performed with new syringes or dose-delivery systems and distilled water. A DNI Nevada Infutest 2000 Series D infusion pump analyser was used to measure the delivered doses and occlusion pressures. Tests performed were: 1) human factors (dose-delivery system, displays, dose-request control, and ease of use); 2) performance (flow and dose-volume accuracy, battery power, memory function, and data logs); and 3) safety features (anti-free-flow mechanisms, dose-interval range (lockout), occlusion (overpressure) alarm, alarm characteristics, and resistance to tampering and accidents).
Results (if applicable)	The pumps exhibited varying levels of performance, resistance to accidents and tampering, and ease of use. Six were rated acceptable (Abbott Laboratories Abbott Pain Manager (APM) II, Baxter Healthcare 6060 Multi-Therapy Infusion Pump, Baxter Healthcare Ipump Pain Management System, Baxter Healthcare PCA II, SIMS Deltec CADD-Legacy PCA Model 6300, and the SIMS Graseby 3300 PCA). While none of the six units stands out as ideal, they meet most criteria. One other pump was rated acceptable (with conditions) (Abbott Laboratories LifeCare 4100 PCA Plus II Infuser) because in one of its operating modes, it has a drawback that could be dangerous to patients. Two pumps were rated Not Recommended (McKinley Medical EpM and Sorenson MicroJect PCA) because they both have a significant number of disadvantages.
Implications	Not reported.

Study details	Ashburn, 1994[2]
Country of publication	USA
Topic category	EQI
Focus of research	Prevalence (extent of problem)
Type of study or article	Prospective observational study
Aims/ Objectives	To identify the underlying causes of respiratory-related critical events associated with intravenous patient-controlled analgesia (IV PCA).
Description of study and methods	An Acute Pain Service (APS) was established for the management of all patients receiving IV PCA therapy for pain management. As part of ongoing care, all respiratory-related critical events were documented and analysed by staff members of the APS team. All patients receiving IV PCA therapy through the APS during the period of May 1990 to October 1992 were enrolled in the study.
Results (if applicable)	A total of 3785 patients received PCA therapy for a total of 11,521 patient care days. Fourteen critical events occurred, of which four led to increased patient care. There were eight programming errors (all involving misprogramming of the continuous infusion): three involved a family member activating the device, three were the result of an error in clinical judgment and one involved a patient tampering with the device. Of the four events that led to increased patient care, two involved a family member activating the device, one was the result of a programming error and one was the result of an error in clinical judgment. All patients who experienced a critical event had an uneventful recovery.
Implications	It was determined that the design of the PCA device contributed to the misprogramming errors and the device was removed from service. Changes in the training of physicians and nurses were instituted to avoid recurrence of other errors identified. The incidence of serious respiratory-related critical events was 0.1%. IV PCA therapy has the risk of potentially serious complications and requires constant physician and nursing care with an active quality assurance programme. In this study, the patient who tampered with the device was unsuccessful in accessing the opioid. Almost all PCA devices have an alarm which sounds when the device is tampered with. The authors conclude that other safeguards do not seem necessary in their clinical practice.

Study details	Blanc, 1995[3]
Country of publication	Unclear
Topic category	EQI
Focus of research	Prevalence (extent of problem) study
Type of study or article	Survey: Retrospective record review
Aims/ Objectives	To determine the incidence of laparoscopic management of malignant ovarian cysts.
Description of study and methods	Retrospective, multi-institutional French survey, carried out from April to October 1992. 7122 ovarian lesions were examined laparoscopically and 5307 of these were treated including 78 malignant tumours.
Results (if applicable)	Findings suggest that laparoscopic management of ovarian lesions that subsequently prove to be malignant is not uncommon. In 22.4% of the patients presenting lesions in this study, laparoscopic tampering resulted in an upgrading of FIGO stage.
Implications	To prevent the risk of metastasis, thorough pre-operative and pre-operative evaluation is mandatory.

Study details	Dunbar, 1995[4]
Country of publication	USA
Topic category	EQI
Focus of research	Prevalence (extent of problem) study
Type of study or article	Retrospective review of case records
Aims/ Objectives	To present a retrospective review of the use of patient controlled analgesia (PCA) in 39 preteen children and to describe the methodology for PCA used in this age group.
Description of study and methods	The authors retrospectively reviewed records for all patients who used PCA and were aged 12 years or under (n=39, age range 4 to 12 years, 21 male and 18 female). The children were taught how to use the PCA by experienced pediatric nurses who also adjusted the dosages within the limits prescribed by the Pain and Toxicity Service.
Results (if applicable)	PCA was reported to be safe and effective for 37 of the 39 children (95%). Only two children failed to benefit from PCA. No child in the study overdosed. The authors observed no instances of drug misuse, parental tampering, accidental overdose, or difficulty weaning from opioids.
Implications	The authors conclude that opioid PCA, with or without continuous infusion (CI), over several days or weeks is safe and effective for preteen children suffering bone marrow transplantation (BMT)-related pain.

Study details	Patenaude, 1986[7]
Country of publication	USA
Topic category	EQI
Focus of research	Vulnerability assessment
Type of study or article	Theoretical computer model
Aims/ Objectives	To describe the structured assessment approach (SAA) used to assess the vulnerability of safeguard systems to insiders in a staged manner.
Description of study and methods	For physical security systems, the SAA identifies possible diversion paths which are not safeguarded under various facility operating conditions and insiders who could defeat the system via direct access, collusion or indirect tampering. For material control and accounting systems, the SAA identifies those who could block the detection of a material loss or diversion via data falsification or equipment tampering. The SAA runs on a personal computer. The SAA input is a text-like data file, is easily readable and can provide documentation of facility safeguards and assumptions used for the analysis.
Results (if applicable)	Only the process and not the results are reported.
Implications	The SAA program allows for a computer-aided step-by-step analysis of vulnerabilities for physical security and material accounting systems. At each step, the program aids the assessor in keeping the facility description logically consistent and in revealing vulnerabilities that may not have been apparent using informal analysis. The program provides the framework for building up a detailed description of the facility in a way that can significantly increase the thoroughness of safeguards evaluation and documentation.

Study details	Phillips, 1995[8]
Country of publication	USA
Topic category	EQI
Focus of research	Intervention study
Type of study or article	One group post-evaluation
Aims/ Objectives	To evaluate the performance of the Alcopatch, a tamper-evident transdermal dosimeter for the measurement of alcohol consumption.
Description of study and methods	The Alcopatch comprises a flexible adhesive band worn completely encircling the ankle and sealed at both ends with tamper-evident tape. The tape seems superficially similar to opaque vinyl adhesive tape but when it is stripped away from a surface, part of the adhesive is left behind so that multiple images of the word 'VOID' appear. The images do not disappear if the tape is reapplied. A group of 14 normal volunteers (13 M, 1 F, mean age 32.5 years) was recruited. Two Alcopatches were applied, one to each ankle. The volunteers were asked to keep a complete written record of all alcoholic beverages consumed over the subsequent 7 to 8 days. When they returned the Alcopatches were removed for assay.
Results (if applicable)	All alcohol consumption in excess of 0.25 g/kg/day resulted in measurable levels of ethanol in the Alcopatch. A positive correlation was observed between the reported consumption of ethanol (in g/kg/day) and the concentration of ethanol in the Alcopatch. No Alcopatches showed signs of tampering.
Implications	The Alcopatch may be most useful in the future as a means of monitoring alcohol consumption by people whose self-reports are potentially unreliable. Other implications: tamper-evident tape as described here may have useful applications. It was originally developed in response to a need in the financial community to detect tampering with sealed bags containing valuables.

Study details	Shapiro, 1993[5]
Country of publication	USA
Topic category	EQI
Focus of research	Prevalence (extent of problem) study
Type of study or article	Retrospective record review
Aims/ Objectives	To delineate dose ranges, utilisation patterns, and frequency and types of problems encountered by patients with sickle-cell haemoglobinopathies who used patient-controlled analgesia (PCA) for the management of vasoocclusive pain.
Description of study and methods	Between April 1988 and July 30 1990, medical records of 92 patients with sickle cell disease who received PCA were available for review. 79 charts contained all the information necessary for a complete database. Data on attempts, injections, amount of opioid consumed and physicians' and nurses' notes were retrieved.
Results (if applicable)	Patients varied widely in the drug administered, use of basal infusion, individual dose and total amount of drug received. On the day of heaviest use, the average maximum hourly dose was equivalent to 0.09 mg/kg of morphine. In this study, 11 patients and two families disliked PCA, one patient had respiratory compromise and one patient tampered with the machine as a suicidal gesture. The patient who tampered with the machine disliked PCA because it 'gave too much medicine'.
Implications	Patient satisfaction with PCA probably reflects interactions among the psychosocial impact of chronic illness and chronic pain, individual psychological and temperamental factors, environmental contingencies, and the expectations and beliefs of the family and the health-care professionals. Most PCA devices are resistant to tampering; the supply of opioid is locked, and using the machine without the proper code sets off an alarm. Conventional intravenous infusion systems are not locked and are more available to unauthorised changes. Tampering does not represent a problem specific to PCA. All such behaviour must be taken seriously. The patient received intensive individual and family psychotherapy after the tampering.

Study details	Srinivasen, 1998[b]
Country of publication	USA
Topic category	EQI
Focus of research	Prevalence (extent of problem)
Type of study or article	Prospective monitoring study
Aims/ Objectives	To study frequency of home ventilator failure, apparent causes for the failure or malfunction and adverse consequences following the failure.
Description of study and methods	Information on all requests to correct home ventilator failures reported to a home respiratory equipment vendor was collected prospectively between November 1991 and November 1992.
Results (if applicable)	There were 150 ventilator-assisted patients aged 2 to 77 years; 44 were 18 years or less. They received average 15.4h/day home mechanical ventilation. There were 189 reports of home ventilator failure. Defective equipment or mechanical failure was found in only 39% (73 reports), equivalent to one home ventilator failure for every 1.25 years of continuous use. Other causes of ventilator failure included the following: improper care, damage or tampering with the ventilator by caregivers (13%), functional equipment improperly used by caregivers (30%), equipment functional, but patient's condition changed, mimicking ventilator failure (3%). No problem could be identified in 16%. The following actions were required: ventilator replacement (44%), repair of a defective part (6%), replacement of a functioning ventilator for psychological comfort (14%), ventilator adjustments made (21%), caregiver reeducation (7%), caregiver anxiety or distress reduced (3%) and no action required (4%). Hospitalisation was required in only 2 cases. No adverse outcomes, deaths or serious injuries were associated with home ventilator failure.
Implications	Improper equipment care, damage or tampering by caregivers was responsible for 13% of reported ventilator failures and 30% of failures were due to functional equipment being used incorrectly by caregivers. Improved patient and caregiver education and support may reduce reports of home ventilator failure. In this study, none of the reported damage or tampering by caregivers appeared to be malicious, and most was dealt with by providing ongoing education.

TOPIC: DRUGS

Study details	Cassells, 1998[18]
Country of publication	UK
Topic category	DRU
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To investigate the effects of 15 chemicals and household agents on an enzyme immunoassay (EIA) for LSD.
Description of study and methods	LSD stock solution was prepared and stored at -20C for up to 8 months. Drug-free urines were pooled and stored at room temperature. Fifteen compounds were chosen for adulteration of urine, due to their ease of availability or to reports of their previous use or effectiveness in interfering with drug screening techniques. Solutions of the adulterants (1% and 10%) were mixed for 30 minutes and stored at room temperature overnight. On the following day the samples were examined and their appearance and smell were recorded. The pH and specific gravity of the samples was measured. Enzyme immonoassay and solid phase extraction (SPE) methods were used to analyse the samples and the results were confirmed using LC-MS.
Results (if applicable)	At 10% concentration, ascorbic acid, bleach, limescale remover, and sodium bicarbonate were outside the 4.6 to 8.0 pH range considered normal for urine, and ascorbic acid, salt, methanol, sodium bicarbonate and soluble aspirin fell outside the 1.007 to 1.035 specific gravity range, adopted as normal for urine. Under the test conditions, ascorbic acid, salt, liquid soap, glutaraldehyde, golden seal root, sodium bicarbonate, blood and soluble aspirin at 10% all produced false positive results with LSD-negative urines. Soap and gluteraldehyde at 1% were also sufficient to produce positive results.
Implications	The presence of certain compounds or products can significantly alter the results of an enzyme immunoassay, in this case an EIA for LSD.

Study details	Cheung, 1991[19]
Country of publication	USA
Topic category	DRU
Focus of research	Detection
Type of study or article	Equipment evaluation
Aims/ Objectives	To address the questions: 1) what are the reproducibility and reliability of refractive index measurements of drug solutions?; 2) Are they dependent on the refractometers used?; 3) What are the within-day and between-day variabilities of these measurements?; 4) What commonly used solutions of controlled substances can be screened by this approach?; and 5) Are there ways by which such refractometric screening can be subverted?
Description of study and methods	Four different refractometers were tested. Three were hand-held models, and one was a desk-top model that provides automatic digital readings and was therefore used as a reference instrument with which the hand-held refractometers were compared. Tap water and double-distilled water were obtained in the lab, and 0.9% sodium chloride solution and 5% dextrose injection were obtained. In the within-day variability study, each drug and control was tested five separate times on the same day with refractometers A and B. The between-day variability was determined for two solutions by comparing the mean values obtained from five individual readings on five consecutive days. One person performed all the refractometer readings so that inter-operator variability was eliminated in this study.
Results (if applicable)	Concordance among refractometers: The correlation coefficient for values obtained with refractometers A and B was 0.9995, confirming that the refractive index and Brixscales were well correlated for the drug solutions tested and that the two refractometers provided consistent measurements between themselves. Variability: The mean values for the within-day variability study obtained during the first day of the experiment were identical to the composite means obtained after five days of measurements. For the two solutions used, the variabilities arising from using refractometer A were substantially less than those of refractometer B. With refractometer B, however, the variability decreased when the solid content of the solution increased. Refractometric values: The solutions used provided either too little dissolved content or too high a concentration for measurement by refractometers A and B. However, refractometer C did provide measurements for the solutions. Effect of dilution: Invariably, refractive index was a linear additive function of the concentration of solutes in solution, whether the diluent was water, or either of the other two solutions. Returned injections: 83 injections of controlled substances (six different preparations) that been returned to the pharmacy were also studied. Of these 76 (92%) had a refractive index that was 99-100% of that measured in a previously unopened sample of the same product. Five injections (6%) had a value that was 94-98% of the appropriate reading.
Implications	Despite some limitations (described fully in the paper), hand-held refractometers appear to be useful tools for pharmacists in monitoring the integrity of drug solutions. Little training is required, and the amount of sample required per test is only about 100 microL. The screening procedure is rapid, simple, reproducible, and inexpensive and is applicable to a wide array of drug solutions.

Study details	Dietz, 1988[9]
Country of publication	USA
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To review publications that advocate the use of product tampering and other poisoning methods as techniques for exacting revenge against individuals and corporations, as methods of committing murder, and for other criminal purposes. Several of the particular techniques recommended in these publications have been used subsequently in criminal tampering incidents.
Description of study and methods	The published sources of technical guidance for the would-be tamperer and poisoner are examined in detail to alert forensic scientists, law enforcement authorities and the food and drug industries to the particular techniques that are being advocated. Possible criminal and civil liability of the publishers and authors is discussed.
Results (if applicable)	No results as such. Discussion of the content of various manuals, such as methods and substances used to adulterate alcoholic drinks, cigarettes, drug capsules etc. Refers to the Tylenol incident.
Implications	The author suggests that food and drug retailers consider the wisdom of selling magazines that advertise the availability of revenge and murder manuals advocating product tampering and poisoning, that food and drug manufacturers test the effects on their products of the contaminants that are being recommended and that investigators be alert to the existence of such manuals and mail-order supplies of poisons.

Study details	Eagle, 1994[20]
Country of publication	Canada
Topic category	DRU
Focus of research	Intervention study
Type of study or article	Laboratory tests
Aims/ Objectives	To assess the value of refractometry in identifying the contents of a variety of opioid-containing solutions.
Description of study and methods	A hand-held refractometer was used to document the refraction produced by the undiluted contents of alfentanil, fentanyl, morphine, sufentanil ampoules and by solutions on Ringer's lactate, 0.9% saline, 3.3% dextrose in 0.3% saline and distilled water. Each opioid was then serially diluted in serial 1:2, 1:4 and 1:8 dilutions in each of these solutions and the refractions of each determined. Based on this information, blinded identification of various diluted opioid solutions was attempted.
Results (if applicable)	Refractometer values for undiluted fentanyl and sufentanil were identical with those for distilled water. Those for undiluted alfentanil and morphine were almost identical with each other and with 1:2 and 1:4 dilutions of either drug in Ringer's lactate or 0.9% saline.
Implications	Refractometry is an unreliable screening method to detect tampering with opioid solutions.

Study details	Ernst, 2002[10]
Country of publication	UK
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Systematic review
Aims/ Objectives	To summarise data regarding adulterations of Chinese herbal medicines with conventional drugs.
Description of study and methods	Systematic searches on the Medline, Embase, Biosis, Amed, Cochrane Library and CISCOM databases were performed. Search terms are listed. Manufacturers and experts were consulted. No language restrictions (but Chinese databases were not searched). Studies of any design which contained original data relating to adulteration of Chinese herbal medicines with conventional drugs were selected. 22 articles (18 case reports, 2 case series and 4 analytical investigations) were included: most related to oral use of Chinese herbal medicines but in five instances they related to topical applications of Chinese herbal medicines.
Results (if applicable)	The list of adulterants contains drugs associated with serious adverse effects like corticosteroids. In several instances, patients were seriously harmed. One report from Taiwan suggests that 24% of all samples were contaminated with at least one conventional pharmacological compound.
Implications	Adulteration of Chinese herbal medicines with synthetic drugs is a potentially serious problem which needs to be addressed by adequate regulatory measures.

Study details	Ernst, 2002[11]
Country of publication	UK
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To review evidence suggesting that some Asian herbal medicines contain toxic heavy metals or undeclared prescription drugs.
Description of study and methods	The article aims to summarise the recent evidence pertaining to this subject, based on a review of the recent medical literature (Medline, Embase 1990-2001). Discusses Indian and Chinese preparations in particular.
Results (if applicable)	The inclusion of heavy metals could be either intentional for alleged medicinal purposes or accidental. Evidence from various countries implies that toxic heavy metals and undeclared prescription drugs in Asian herbal medicines might constitute a serious health problem. However the majority of the data is anecdotal and insufficient to define prevalence figures.
Implications	The consumer should be informed that 'natural' does not necessarily mean 'free from risk' and that adverse effects as a result of Asian herbal medicines are an undeniable reality. Patients and physicians should be encouraged to talk about the use of Asian herbal medicines and other complementary or alternative treatments and the possibility of interactions of herbal medicines with prescribed drugs. Regulators should consider measures to control this sector of healthcare more effectively. Study is of questionable relevance.

Study details	Goetz, 1994[12]
Country of publication	USA
Topic category	DRU
Focus of research	Detection
Type of study or article	Case control study
Aims/ Objectives	To determine the cause of unexplained postoperative adult respiratory distress syndrome (ARDS)
Description of study and methods	ARDS of uncertain cause was observed in six post-operative surgical patients over a 6 week period in the ICU of a Veterans Affairs hospital. Unexplained ARDS was defined as ARDS in the absence of previously identified common risk factors including infection, sepsis, severe hypotension, massive haemorrhage requiring >7 units of blood transfusion, or aspiration. The control group consisted of 18 consecutive vascular and thoracic surgery patients who underwent operative procedures and were admitted to the ICU during the same period but who did not develop ARDS (minus one whose medical records were not available). The following factors were compared between the two groups: ward room location before ICU admission; ICU bed location; operating room location; all preoperative, intraoperative and postoperative medications; anaesthetic agent; operative procedure; mode of respiratory therapy provided; cell saver use; staff assignment, including nurses, operating room personnel, surgeons and respiratory therapists. Two tailed Fisher exact tests were used for each variable. Laboratory tests were also carried out.
Results (if applicable)	The only significant association discovered between the ARDS cases and potential risk factors was the use of analgesics and of digoxin. All six patients with ARDS received epidural fentanyl infusion while none of the controls did ($p=0.0002$). No other patient in the hospital was receiving epidural fentanyl during the epidemic. As a result of this investigation, the use of fentanyl infusion was discontinued in the Critical Care Center. Lockable infusion devices to maintain narcotic security were purchased and fentanyl use was resumed. Only one of 26 patients who received fentanyl after these changes developed ARDS (and this patient had widely metastatic carcinoma and complicated surgery).
Implications	The authors suspect that one or more individuals removed fentanyl infusate from the bottle and replaced this volume with another substance. Investigations failed to identify an adulterant, however measures to prevent tampering with infusion devices successfully terminated the epidemic. Critical care personnel using fentanyl infusions for analgesia should consider measures to inhibit theft and tampering. Unexplained physiological deterioration in a patient receiving fentanyl infusion should prompt discontinuation of the fentanyl and investigation into the possibility of tampering with the infusate.

Study details	Govindan, 2000[21]
Country of publication	USA
Topic category	DRU
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To investigate a convenient method for the determination of the quality and possible adulteration of goldenseal (a herbal supplement).
Description of study and methods	Thin-layer chromatography (TLC) was used in the analysis. TLC analysis was performed on 10 goldenseal samples using two solvent systems and spray reagents.
Results (if applicable)	Five of the samples contained both hydrastine and berberine, four contained berberine and one did not contain either of these alkaloids. The TLC results were verified by HPLC analysis.
Implications	These results indicate that TLC is a viable method for the qualitative analysis of goldenseal products but high-pressure liquid chromatography (HPLC) remains the best available method for the quantitative estimation of the active alkaloid content in these products.

Study details	Hadzija, 1996[22]
Country of publication	USA
Topic category	DRU
Focus of research	Detection
Type of study or article	Laboratory tests: controlled study using samples
Aims/ Objectives	To apply high-performance liquid chromatography (HPLC) for the separation and quantitation of hydrocodone (HCD) for application to the analysis of the drug in the sustained-release suspension of Tussionex Pennkinetic.
Description of study and methods	Six samples of Tussionex were brought for analysis: five were the object of a complaint of tampering with the content of HCD. The HPLC method was used to determine the concentration of HCD in these five samples and a control sample. The investigators were blind as to which sample was the control sample.
Results (if applicable)	All samples except the control sample had much less concentration of HCD than the label claimed.
Implications	The proposed analytical method is specific, accurate and rapid, and is suitable for routine analysis of Tussionex formulations.

Study details	Hamilton, 2000[13]
Country of publication	USA
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Descriptive study
Aims/ Objectives	A report of the demographics and clinical characteristics of an epidemic of poisoning caused by heroin adulterated with scopolamine.
Description of study and methods	A descriptive study of patients in New York and other East Coast cities who presented to emergency departments in the spring of 1995 with poisoning caused by heroin adulterated with scopolamine. Drug specimen assays were used to confirm the presence of scopolamine-adulterated heroin products in all four cities.
Results (if applicable)	A total of 370 cases were reported to the participating poison centres. Of these, 129 were excluded from the final analysis because of insufficient data. Of the patients who used the product, 55% presented with signs and symptoms of heroin toxicity but then became severely agitated with anticholinergic symptoms when naloxone was used to reverse respiratory depression. Nasal insufflation was the route of administration in 34% of the cases. Seizures were rare (3%).
Implications	Adulteration of street drugs can lead to toxic epidemics. Poison centres are essential for identification of these trends and are the primary source of information on diagnosis and treatment. Although the report gives detail on this epidemic of poisoning, the aim of the study appears to be the promotion of the need for poison centres.

Study details	Huang, 1997[14]
Country of publication	Taiwan
Topic category	DRU
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To screen samples of traditional Chinese medicines in Taiwan, suspected of adulteration, that were used by the patients in several major hospitals. It was purported to serve as a basic model of incorporating hospitals into a safety-monitoring system for traditional Chinese medicines.
Description of study and methods	A total of 2,609 samples were collected over a period of 1 year from 8 participating hospitals. Each sample was referred by participating physicians in accordance with established procedures. Patients were asked about their experiences with traditional medicines during outpatient visits when their chief complaints or symptoms indicated signs of adverse reactions caused by suspected synthetic adulterants. Analytical methods adopted in this study were based on the National Laboratories of Foods and Drugs (NLFD) established standard procedures and were distributed to participating hospitals to follow. Suspect samples were processed and tested by established methods according to their water or ethyl alcohol solubility and interference by other herbal constituents. If any adulterant failed to be detected and confirmed in suspect samples through thin-layer chromatography, gas chromatography, infrared or gas chromatography/mass spectroscopy were performed.
Results (if applicable)	A total of 618 samples among the 2,609 samples tested were adulterated with unlabeled, synthetic therapeutic substances. The average positive finding of adulteration was 23.7% (range 13.0 to 38.6%). Such findings are consistent with previous laboratory records of the adulteration rate reported by NLFD over fiscal years 1991 to 1993. It showed 27.7%, 25.3% and 22.3% for 1991, 1992, and 1993 respectively, of adulterations in traditional Chinese medicines that were referred through consumer complaint services to local health authorities.
Implications	The authors recommend that health authorities in Taiwan continue to monitor and to provide screening services to the public for traditional medicine. This monitoring program provides a mechanism to identify adulterated traditional medicines. Public education on health hazards of such adulteration should be advocated. In addition, legislative requirements on adequate labeling of dispensed medicines, showing particularly the name of the product or its ingredients, is essential in enforcing prohibition of such hazardous practices. As for the countries that have not established adequate regulations covering the distribution of traditional Chinese medicines, the appropriate health authorities should be made aware of the potential hazards in such illegal adulterations to the health of their public.

Study details	Infante, 1999[15]
Country of publication	Spain
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Laboratory testing
Aims/ Objectives	To analyse illicit heroin from Andalusia (southern Spain) in order to quantify its contents in some metals with a view to examining a new aspect of the conditions under which it is taken by addicts.
Description of study and methods	A total of 196 illicit heroin samples were analysed to determine the contents of various metals (cadmium, calcium, copper, iron, manganese and zinc). The data obtained from the samples was subjected to a statistical analysis. The variables considered were: source, colour, and concentration of each metal in micrograms of metal per gram of heroin.
Results (if applicable)	Calcium was found in 93.4% of the samples and always at high concentrations, which can be ascribed to adulteration of the heroin by addicts with thinners and excipients containing salts of this metal such as calcium bicarbonate. Also, all samples were found to contain variable amounts of zinc and substantial amounts of iron, probably because it is the most common metal found in metal containers used in the extraction of morphine from the opium poppy. Only cadmium and, to a lesser extent, zinc, copper, and iron, are among the metals detected in heroin that can increase the inherent toxicity of the drug while always taking into account the maximum values.
Implications	The results show that, in some cases, the presence of a given metal in heroin can be related to the presence or absence of another metal. Based on the results, it was concluded that the potential toxicity of the metals studied at the concentrations found is relatively low. Only cadmium, and to a lesser extent, zinc and copper and always at the highest concentrations found, might add to the intrinsic toxic effect of the drug. In any case, the susceptibility of each individual must always be considered, such as the effect of cumulative doses due to the frequency of the drug's administration.

Study details	Jenkins, 1985[23]
Country of publication	USA
Topic category	DRU
Focus of research	Intervention study
Type of study or article	Cost-benefit analysis
Aims/ Objectives	To examine the significance of cost savings by preparing selected continuous IV infusions in a standard concentration as opposed to a varied concentration.
Description of study and methods	Data on 48 patients receiving maintenance doses of aminophylline administered by continuous infusions and 31 patients receiving maintenance doses of heparin by continuous infusion were collected. The orders were analysed to determine standardised concentrations for the study. The cost of preparing the infusions as originally written was compared with what the cost would have been if a standard had been utilised. Those costs included the cost of drugs, IV solutions, needles and syringes, alcohol swabs, tamper-proof seals and employee time.
Results (if applicable)	The results project an annual savings, when utilising a standard concentration, of $6,600 - 11,100 for aminophylline and $3,800 - 3,900 for heparin.
Implications	Additional advantages include recycling, decreased preparation time, ease of dosage calculations and adjustments and increased accuracy. No further mention of tamper-proof seals.

Study details	Liu, 2001[24]
Country of publication	Singapore
Topic category	DRU
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To develop an analytical technique to rapidly screen for undeclared toxic and therapeutic substances in Chinese proprietary medicines (CPM).
Description of study and methods	A high-performance liquid chromatography-diode-array detection method was developed and used to screen for undeclared therapeutic substances in CPM. An ultraviolet (UV) library of 266 drugs had been compiled. Solute identification was performed by comparing the analytical data (UV spectra, retention time and relative retention time) with those of the 266 standards. Gas chromatography-mass spectrometry was used as a confirmation method. These chromatographic methods had been shown to be selective and reproducible in screening for undeclared therapeutic substances.
Results (if applicable)	CPM extracts containing 35 spiked drugs were screened by HPLC. All of the spiked standard drugs were successfully detected and identified by the described HPLC screening method. Then, using the method developed, 41 CPM samples in seven categories were screened for undeclared therapeutic substances. One anti-asthmatic CPM was found to contain codeine.
Implications	The screening and identification of undeclared therapeutic substances in CPM is a very challenging task. The chromatographic methods in this study have been shown to be selective and reproducible. Of the 41 samples, only one was found to contain undeclared codeine. Greater awareness of and control over the safety and quality of CPM are necessary.

Study details	Narang, 1995[16]
Country of publication	India
Topic category	DRU
Focus of research	Prevalence (extent of problem) study
Type of study or article	Laboratory tests
Aims/ Objectives	Objective appears to be to determine arsenic levels in Indian tobacco.
Description of study and methods	Sixty tobacco samples were obtained from individuals who used it for smoking or chewing, from surrounding areas of Ludhiana, Punjab. There were 26 samples of chewing and 34 samples of smoking tobacco. Arsenic was measured by a spectrophotometric method. The results were compared with the atomic-absorption spectrophotometer and neutron-activation methods.
Results (if applicable)	The arsenic present in the 60 samples of tobacco was in the range of 0.03 to 2.47 ppm (ug/g). The mean arsenic in the 26 chewing-tobacco samples was 0.404 ppm (SD 0.329) with the range of 0.03 to 1.08 ppm. Arsenic in the 34 samples of smoking tobacco was 0.642 ppm (SD 0.635) with the range of 0.03 to 2.47 ppm. No significant difference could be obtained between arsenic levels of chewing and smoking tobacco.
Implications	Suggests adulteration of tobacco with arsenic.

Study details	Ostrowsky, 2002[17]
Country of publication	USA
Topic category	DRU
Focus of research	Detection
Type of study or article	Case-control study
Aims/ Objectives	From June 30, 1998 to March 21, 1999 several patients in the surgical intensive care unit of a hospital acquired Serratia marcescens bacteraemia. The authors investigated this outbreak to define the extent of the problem, identify the source and risk factors and implement control measures.
Description of study and methods	Compared patients with S Marcescens bacteraemia with randomly selected controls. Isolates from patients and from medications were evaluated by pulsed-field gel electrophoresis. The hair of one employee was tested for fentanyl.
Results (if applicable)	According to univariate analysis, patients with S marcescens bacteraemia stayed in the surgical intensive care unit longer than controls (13.5 versus 4.0 days $p<0.001$), were more likely to have received fentanyl in the surgical intensive care unit (odds ratio 31, $p<0.001$) and were more likely to have been exposed to two particular respiratory therapists (ORs 13.1 and 5.1, $p<0.001$). In a multivariate analysis, receipt of fentanyl and exposure to the two respiratory therapists remained significant. One respiratory therapist had been reported for tampering with fentanyl; his hair sample tested positive for fentanyl. Cultures of fentanyl infusions from two case patients yielded S marcescens and E cloacae. The isolates from the case patients and from the fentanyl infusions had similar patterns on pulsed-field gel electrophoresis. After removal of the implicated respiratory therapist, no further cases occurred.
Implications	Theft of narcotics and the potential for resulting complications in patients remain a problem in health care settings. Hair testing may be useful. In this hospital, although there was a policy that theft of narcotics should be investigated, there were no adequate mechanisms in place to deal with theft of patients' medications or possible resulting adverse events.

Study details	Read, 1975[25]
Country of publication	Unclear
Topic category	DRU
Focus of research	Intervention study
Type of study or article	An evaluation study, recording time, costs, laboratory cultures, medication errors and global evaluation of a new procedure compared to the old procedure.
Aims/ Objectives	A programme of preparing respiratory therapy solutions and medications administered by the respiratory therapy department in a tamper-proof, disposable, unit-of-use package was developed and evaluated.
Description of study and methods	The original (old) delivery system required the pharmacy to supply the solutions in multiple dose containers; from these the respiratory therapy technician performed any additional mixing or dilution requirements and transferred the solution to a disposable syringe. In the new system, solutions were dispensed from the pharmacy to the respiratory therapy department in sterile 3ml disposable syringes prepared aseptically in a laminar air flow hood. The syringe hub was covered with a sterile plastic cap, the syringe placed in a polyethylene bag which was heat-sealed and two labels applied to the bag: 'not for injection' and solution formula/control number. Stock solutions were prepared the same day they were to be packaged and only in the quantity necessary for that batch. Working stock was replaced daily. The evaluation of the study was designed to provide information in the following areas: 1. Personnel time studies, comparing the old system of extemperaneous packaging to the new system of prepackaging. Personnel costs were to be determined from these time studies. Direct observation time and motion studies. 2. Cost of medication and comparison of patient charges. Review of patient records (retrospective). 3. Laboratory culturing of random samples under both systems. 4. Medication errors. 5. Overall benefit to the patient as determined by the respiratory therapy department.

Results (if applicable)	1. Old system: average time for dose preparation 41.7s per dose. New system: 63.3 s per dose. Led to hardly any difference in cost, as pharmacy staff wages were lower than those of respiratory therapy technicians. 2. Average patient cost per dose was higher under the unit dose (new) system. 3. Culturing of random samples failed to indicate contamination in either group although it was noted that certain respiratory therapy technicians demonstrated very poor technique. 4. Under the old system, of 23 samples, 5 were mixed to an incorrect concentration and three contained incorrect volume. This source of error was eliminated under the new system. 5. Major points of the respiratory therapy department's evaluation of the unit dose programme are noted as follows: the unit dose system assured that each patient received the proper medication in the prescribed amount; maintaining a prepackaged supply of stock solutions in the department was beneficial for stat treatments on patients in respiratory distress where time is important; tamper-proof packaging with complete labelling decreased possibility of medication errors; syringes were packaged without needles, eliminating chance of a respiratory therapy technician being infected by a contaminated needle puncture; possibility of medication contamination and nosocomial infection for the patient was eliminated with unit dose packaging; unit dose system eliminated large amounts of wasted medications experienced with the old system; time saving for respiratory therapy staff; unit dose system allowed department to reduce stock supplies, producing savings in time and storage space.
Implications	The evaluation indicated that: personnel costs between the two systems were similar; patient charges increased under the unit dose system by approximately 10 cents per dose; packaging technique and controls improved under the unit dose system; medication errors were reduced. Old, US-based study.

TOPIC: CLINICAL PRACTICE

Study details	Bentur, 1999[27]
Country of publication	Israel
Topic category	PRA
Focus of research	Detection
Type of study or article	Laboratory tests. Pre- and post test study.
Aims/ Objectives	To determine whether digoxin-like immunoreactive substances (DLIS) can be present after death in critically ill patients not treated with digoxin, whether a postmortem increase in DLIS is detectable and whether sampling site affects DLIS concentrations.
Description of study and methods	ICU patients in whom blood samples could be obtained within 48h prior to death and no sooner than 12h after death were enrolled. Blood was drawn from the femoral artery and cardiac chambers. Plasma DLIS concentrations were measured as digoxin by fluorescence polarisation immunoassay. DLIS concentrations, ante-and post-mortem and at different sampling sites, were compared using paired Student's t-test and ANOVA. Linear regression was used to assess the correlation between DLIS concentrations and age, ICU stay and postmortem sampling time and between the ante- and postmortem concentration difference and age, ICU stay and postmortem sampling time. Chi square analysis was applied for comparing the number of patients with measurable antemortem DLIS in patients with and without conditions known to interfere with digoxin determination and to compare the number of patients with postmortem increase of DLIS in both groups.
Results (if applicable)	Twenty-five moribund patients were included over a period of 17 months. DLIS concentrations > or = to 0.05 mg/ml and > or = to 0.2 mg/ml were observed antemortem in 17/25 (68%) and 11/25 (44%) patients, respectively, and postmortem (femoral) in 14/25 (56%) and 10/25 (40%) patients, respectively. Postmortem femoral and cardiac DLIS concentrations increased in 8/25 (0.01-0.52 ng/ml) and 3/13 (0.04-0.68 ng/ml) patients, respectively, without statistical significance (p=0.843). Mean DLIS concentrations did not differ between the three groups. None of the concentrations measured was in the toxic range for digoxin, the highest being 1.94 ng/ml. No correlation was found between the postmortem increase in DLIS and age, ICU stay and postmortem sampling time (p=0.479, 0.835, 0.37, respectively). Significant correlation was found between antemortem and postmortem femoral DLIS concentrations, antemortem and postmortem cardiac concentrations and postmortem femoral and cardiac concentrations (r=0.857, p=0.0000; r=0.825, p=0.0000; r=0.703, p=0.007, respectively). The subset of liver patients who had combinations of renal failure, liver disorder, hypothyroid and drugs affecting digoxin concentrations was subjected to further analysis. Measurable antemortem DLIS was found in 13/17 patients of this group, compared with 4/8 in the rest of the patients (p=0.388). Postmortem increase in femoral DLIS was found in 4/17 of these patients vs 4/8 (p=0.388).
Implications	The results of this study have medical-legal implications in cases where erroneous dosing of digoxin or malicious administration are suspected causes of death. The interpretation of measurable postmortem digoxin concentrations in the therapeutic range should be done cautiously. In patients not previously treated with digoxin such a level may reflect the antemortem presence of DLIS rather than indicating an intoxication with digoxin. The finding of toxic digoxin levels warrants further investigation for elucidating their source. In patients treated with digoxin, the finding of postmortem toxic levels in the absence of antemortem levels hinders interpretation because it is not clear whether they reflect postmortem redistribution of true intoxication.

TOPIC: LABORATORY TESTS

Study details	Baiker, 1994[28]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To report the effects of small amounts of bleach on known concentrations of tetrahydrocannabinol (THC) when measured by radioimmunoassay (RIA), fluorescence polarisation immunoassay (FPIA), and gas chromatography/mass spectrometry (GC/MS).
Description of study and methods	Urine samples containing various known amounts of THC (25-219 ng/mL) were spiked with increasing amounts of household bleach (0-64microL/mL of urine). The samples were extracted using a solid-phase extraction procedure, derivatised, and analysed by GC/MS. The area counts for the deuterated internal standard versus the native drug, as well as the quantification for the various spiked samples, were compared with those of the non-adulterated samples.
Results (if applicable)	There was an inverse relationship between the amount of bleach used and the amount of THC recovered. The area counts for both the deuterated and native THC decreased as the amount of bleach increased. There appeared to be a consistent decrease in the ratio of native to deuterated THC, suggesting that the bleach affected the native drug more than the deuterated compound. The same decrease in THC concentrations was noted when the samples were assayed by an RIA methodology as well as by an FPIA assay.
Implications	The results show that very small amounts of household bleach can significantly affect the quantitation of THC by both immunoassays and GC/MS. The amount of decrease is more dramatically apparent in GC/MS. The results also show that GC/MS and FPIA are more affected by the addition of bleach at minute concentrations than RIA but that all three methods show some effect at any given level of bleach. The cause of the rebound effect could not be determined because it was inconsistent and not universal. It was not possible to determine the product created through the interaction of bleach and THC.

Study details	Barrett, 2001[45]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To report the results of field evaluations of the ORALscreen System for screening of drugs in oral fluid.
Description of study and methods	Paired samples (oral fluid and urine) were collected from drug users and the results from the ORALscreen POCT system were compared to urine screening results conducted in a licensed laboratory. The comparison tests were analysed by gas chromatography-mass spectrometry (GC-MS). The authors also report that numerous compounds were selected to determine the degree of interference which may be caused by over-the-counter or prescription drugs. Additionally, common food and drink which could easily have been present in the oral cavity before testing were studied.
Results (if applicable)	The ORALscreen System was reported to have excellent percentage agreement (95%) with the laboratory-based urine screening test results for the detection of cocaine and opiates through 2.5 to 3 days following drug use. Tetrahydrocannabinol (THC) was detected by ORALscreen on the day of use and 1 day after use. Good correlation between urine and oral fluid screening results was observed for the methamphetamine positive samples, however, the number of days following drug use was not determined.
Implications	The authors state that the advantages of the ORALscreen over a laboratory-based urine screening test include: results obtained at the point-of-collection in minutes, no need for special collection facilities, observed sample collection and no requirement for special laboratory equipment or reagents.

Study details	Beck, 2000[29]
Country of publication	Sweden
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To check for urine adulteration in a Stockholm clinic for young people with drug abuse problems.
Description of study and methods	A total of 594 patient specimens were subjected to Adultacheck test strip screening for nitrite, glutaraldehyde, pH, and creatinine. Creatinine measurement was also performed at the laboratory, together with drug screening using EMIT reagents, and a subsample was spiked with phencyclidine to verify EMIT test function.
Results (if applicable)	The frequency of dilute urine (creatinine <4mmol/L) was 11%. Otherwise no evidence of adulteration was found.
Implications	The Adultacheck strip might be useful in detecting dilute urine specimens already at the clinic, though the test strip levels did not agree well with the respective laboratory results. It was found that adulteration of urine specimens was not common at the clinic, and that specimen collection for urine drug testing could be performed in a reliable manner. Paper written in Swedish.

Study details	Berg, 1999[30]
Country of publication	UK
Topic category	TES
Focus of research	Intervention study
Type of study or article	Uncontrolled pre-post study
Aims/ Objectives	To determine the outcome for children after psychiatric intervention in cases of factitious illness by proxy (Munchausen's syndrome by proxy).
Description of study and methods	17 children from 16 families, selected for admission to the Park Hospital Oxford family unit 1992-6, were followed up after a mean of 27 months. Information was obtained on the children and their carers from general practitioners, social workers or both; 13 of the children and carers were interviewed.
Results (if applicable)	All patients were at the severe end of the abuse spectrum; 12 involving direct induction of illness, 1 tampering with samples to mimic illness and 4 fabrication of symptoms. The biological mother was the abuser in all cases. Four children and their parents had been initially admitted for assessment, and 13 for treatment to decide whether family reunification was viable. The four assessments clarified diagnosis, enabling improved care plans to be made. Of the 13 treatment cases, 10 were reunited with parents after a mean of 7.5 weeks' admission, whereas 3 were discharged to out of home care. There was a further episode of induced illness in one of the reunited children. Although some mothers had continuing mental health difficulties, only 1 of the other reunited cases had appreciable parent-child relationship difficulties (not requiring referral to psychiatric services). The children did well in their development, growth and adjustment.
Implications	Family reunification is feasible for certain cases, but long-term follow-up is necessary to ensure the child's safety and to identify deterioration in parent's mental health. The outcome for reunited children compared well with reported untreated cases. Non-abusive partners, fathers or step-fathers appear to be very important to the outcome. A good outcome was associated with: acknowledgement of the factitious illness by proxy itself and the context of personal mental health difficulties, parenting problems and other psychosocial problems in which it occurred; considerable improvement in personality style or other mental health problems; family system change, usually in the direction of increased openness of factual and emotional communications; increased parental awareness and sensitivity to their children's needs and a realistic acceptance by the abuser of a continuing personal vulnerability and taking steps to prevent recurrence.

Study details	Cody, 2001[31]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing: controlled study using samples
Aims/ Objectives	An analysis of morphine and codeine in samples adulterated with Stealth (an adulterant used to avoid detection of drug abuse).
Description of study and methods	Fresh urine was collected to prepare spiked samples used in the study. Each urine matrix was split into different portions. One portion was used as negative control; the other was spiked with drug(s) at known concentrations. Samples were spiked with 6000ng/mL of codeine and/or morphine glucuronide. The spiked sample was then split and one portion used as a positive control and the other adulterated with Stealth following package directions. A portion of each of these was analysed by immunoassay and gas chromatographic-mass spectrometric (GC-MS) analysis.
Results (if applicable)	The effect of Stealth on opiate immunoassay has been shown to be concentration dependent. Stealth-adulterated urine samples containing 2500ng/mL morphine (25% above cut-off) yielded negative results with both immunoassays. Even with this low concentration of morphine, the immunoassay showed measurable activity and higher concentration samples tested positive. All aliquots from the unadulterated spiked samples were positive in both immunoassays. Confirmation analysis using GC-MS procedures proved unsuccessful with a number of the Stealth adulterated samples. Neither morphine, codeine, not their respective deuterium-labeled internal standards were recovered from four of the 12 adulterated samples despite repeated attempts. Addition of sodium disulfite to the aliquots prior to extraction allowed recovery of the drugs and internal standards from all samples. Analysis of the samples showed the concentration of morphine and codeine decreased in some by as much as 17 and 30%, respectively. In other cases, there was essentially no difference in the concentration seen before and after adulteration, with or without disulfite treatment. Unless the initial concentration of opiate is near the cutoff, samples containing opiates are likely to be immunoassay positive.
Implications	It is important to consider this procedure as an option for samples that screen positive but the opiates and their respective internal standards are not recovered for GC-MS analysis.

Study details	Cody, 2001[32]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To assess the effect of the adulterant "Stealth" (a peroxidase) on various clinical parameters and immunoassay testing for drugs of abuse.
Description of study and methods	Stealth was added to a number of urine matrices, and various parameters were evaluated including pH, specific gravity, colour, creatinine, chloride, urea, blood, glucose, and nitrite. Samples were spiked with THC acid metabolite, benzoylecgonine, morphine, secobarbital, PCP, amphetamine, and lysergic acid diethylamide (LSD) then tested by Roche Online and Microgenics CEDIA immunoassay reagents.
Results (if applicable)	Results of these analyses showed Stealth did not cause the urine sample to exceed any of the monitored parameters including those routinely used in drug-testing laboratories that would indicate adulteration of a sample. It did, however, cause samples positive for the marijuana metabolite, LSD, and opiate (morphine) at 125-150% of cutoff to screen negative by immunoassay. Adulterating an authentic positive sample provided by a marijuana user caused that sample to screen negative using these immunoassay reagents as well.
Implications	Addition of Stealth to urine samples does not result in a change that would be detected by current routine analyses designed to identify adulterated specimens.

Study details	Cone, 1998[33]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Uncontrolled pre-post test
Aims/ Objectives	To investigate the effects of excessive fluid ingestion on immunoassay test results following marijuana and cocaine administration.
Description of study and methods	Seven volunteers were involved in the study. Several flushing conditions were part of the evaluation, including a commercial product sold specifically for flushing, Naturally Klean Herbal Tea (Klean Tea); Golden Seal root capsules taken with excess water; and a commonly used diuretic medication (hydrochlorothiazide) taken with excess water. Two different immunoassays were used to test specimens to determine if results were comparable and to obtain both qualitative and semi-quantitative measures. Flushing results were compared with control conditions in which only a small amount of water (12 oz) or excess water (1 gallon) was ingested.
Results (if applicable)	The ingestion of large amounts of fluid produced rapid declines in creatinine and specific gravity to levels indicative of deliberately diluted specimens. Marijuana and cocaine immunoassay test results also showed rapid decreases in metabolite concentration and results frequently switched from positive to negative. By the time participants had consumed 2 qt of fluid, they were generally producing false-negative results. Recovery of urine test measures to pretreatment levels occurred over a period of 8-10 hours after the start of fluid ingestion. All of the dilution effects appeared to be related to water ingestion, and the inclusion of Klean Tea, Golden Seal or hydrochlorothiazide had no obvious additional effect.
Implications	It was concluded that claims of 'flushing' and 'cleansing' for the herbal products were not accurate and that ingestion of large amounts of water was responsible for the production of false-negative urine test results.

Study details	Critchfield, 1993[34]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To test whether an antibody-mediated interference could arise in a homogeneous immunoassay used to determine the presence of cocaine metabolites in urine.
Description of study and methods	There were two parts to the study: 1) to determine the amount of excess concentrated antibody-containing protein necessary to cause negative interference; and 2) to establish that the interference did not arise from non-specific binding. Urine specimens containing benzoylecgonine (BE) at concentrations near the National Institute on Drug Abuse (NIDA) threshold were assayed in replicate determinations by EMIT. Excess reagent protein (containing antibody specific for cocaine metabolites) was added to specimens to test for an antibody-mediated interference. A linear model was used to compare the change in absorbance at various excess reagent protein concentrations. A non-zero slope of the regression curve (for each experiment) at a p value less than 0.05 was judged to be statistically significant.
Results (if applicable)	Replicates of the BE-fortified specimens tested by EMIT that did not contain excess reagent antibody were all positive by the assay, while those that contained the excess reagent antibody were all negative.
Implications	Whether antibody-mediated interference is a practical problem at the present time is unknown. Because it may be difficult to detect excess interfering antibody by using some traditional tests for urine adulteration, these findings are presented to illustrate a potential problem for some homogeneous immunoassays in forensic urine drug testing programmes. Further investigation of these findings may help to delineate the possible magnitude of the problem and provide methods less susceptible to this potential interference.

Study details	Ferslew, 2001[46]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To test the application of capillary ion electrophoresis (CIE) for the direct detection of anionic concentrations in normal human urine and urine specimens suspected of adulteration.
Description of study and methods	CIE was performed using an electrophoresis system with either direct or indirect ultraviolet absorption detection at 254 nm. Analytical standards of the anions of interest; bromide, chloride, fluoride, nitrate, nitrite, phosphate, and sulfate, were prepared from stock standards. CIE of 30 random normal urine specimens and 21 urine specimens suspected of adulteration was performed. Duplicate aliquots were assayed by CIE and by colorimetric technique for nitrite.
Results (if applicable)	Sixteen specimens had elevated concentrations of nitrite and/or nitrate. The correlation coefficient between nitrite CIE and colorimetric results was 0.9895. Three specimens had detectable concentrations of chromate and were suspected of being adulterated with "Urine Luck", an adulterant found to contain chromate. Two specimens suspected of being adulterated with bleach were found to only contain chloride, sulfate, and phosphate.
Implications	CIE is applicable to forensic analysis of urine anion concentrations. CIE can easily quantitate numerous endogenous anions and offers a method to detect and/or confirm anion adulteration of urine specimens.

Study details	Jones, 2000[47]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing: controlled study using samples
Aims/ Objectives	To determine whether the methylene blue method was suitable for the detection of anionic surfactants (detergent) in forensic urine drug test specimens that were suspected of adulteration.
Description of study and methods	Each calibrator, control, and suspect sample was measured by spectrophotometry using a wavelength of 652 nm against a reference of pure HPLC-grade chloroform. All calculations were based on Beer's Law. Donor specimens were reported as positive/negative for anionic surfactants (detergent) as methylene blue active substances (MBAS), calculated as sodium dodecylbenzene sulfonate (DBS), relative to the calibrator. The linearity of the methylene blue procedure was determined by plotting the mean of the first five results obtained for a variety of concentrations. A set of 15 replicates was analysed to determine the precision of the methylene blue procedure for the negative controls. The accuracy of the methylene blue procedure was determined by checking the potential for overlap between the negative controls using a range of two standard deviations from each of their means. Negative analysis: A group of 100 donor urine specimens that exhibited no unusual foaming when shaken were selected and analysed. The calculated mean was 8.73 ug/mL (range -3.12 ug/mL to 36 ug/mL). Positive analysis: 13 donor urine specimens that were considered unsuitable for testing were analysed. Spikes: 6 60-mL CNU specimens were spiked with various detergents and were analysed by the methylene blue procedure.
Results (if applicable)	Most of the suspected adulterated specimens and spiked samples with only 100 uL of detergent in 60 mL of urine had values greater than 750 ug/mL. Based on the analysis of negative samples, a urine specimen with an anionic surfactant level of 100 ug/mL or greater could be considered adulterated and most likely will have levels greater than 800 ug/mL.
Implications	Indicators for detergent testing may include immunoassay interference and/or confirmatory gas chromatography-mass spectrometry analysis difficulties. The extent of interference depends upon the type of immunoassay reagent used, the pH of the specimen, the concentration of other constituents in the specimen, the concentration of the surfactant, and the type of surfactant used. This analysis for detecting anionic surfactants in urine can be used along with other indicators such as the physical presence of unusual foaming and/or odor to support the forensic determination that a specimen is adulterated by a detergent.

Study details	Mikkelsen, 1988[35]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To investigate eight readily available substances claimed to cause false-negative results when added to urine that would otherwise test positive by the EIA screening assays for illicit drugs. To identify effective means of detecting urine specimens that are contaminated so that an unadulterated specimen may be obtained.
Description of study and methods	Table salt, Visine eyedrops, household vinegar, liquid laundry bleach, concentrated lemon juice, caustic household cleansers, golden-seal tea and liquid handsoap weere obtained. Adulterated urine specimens were analysed to determine if the adulterants could be indentified, adding adulterants at several concentrations to 222 EIA-positive specimens confirmed by gas chromatography and mass spectrometry (GC/MS) to contain illicit drugs. To identify adulterated urines, pH, relative density and urine colour and turbidity were monitored at adulterant concentrations that falsified EIA results.
Results (if applicable)	Specimens contaminated with salt had relative density >1.035. Liquid Drano, bleach and vinegar shifted urine pH outside the physiological range. Golden-seal tea caused a dark appearance and specimens containing liquid soap were unusually cloudy. Lemon juice had no effect on the assays. Visine was the only adulterant not detected.
Implications	The adulterants interfered somewhat differently with each of the drug assays. EIA assays for illicit drugs can be invalidated by specimen adulteration producing false-negative results. Therefore, if urine drug testing is to be conducted, pH, relative density and appearance should be assessed and suspect specimens should be rejected. Not all adulterants can be detected, so observed collection is strongly recommended.

Study details	Sanchez-Lopez, 2000[36]
Country of publication	Spain
Topic category	TES
Focus of research	Prevalence (extent of problem) study
Type of study or article	Controlled study
Aims/ Objectives	To prove that handling fresh foods prepared for prick-prick tests with latex gloves can tamper with the results in patients with latex allergy.
Description of study and methods	Eleven (11) patients previously diagnosed with allergy to latex proteins (according to clinical history, skin tests and serum specific IgE) and 10 healthy controls were selected. Prick-prick tests with pear, chicken and squid and prick tests with latex were administered. Patients and controls had stopped taking antihistamines at least 5 days before the skin test (6 weeks for astemizole and 1 month for systemic corticosteroids).
Results (if applicable)	Statistically significant differences were found ($p<0.001$) between patients and controls in the prick-prick tests against the different foods after handling with latex gloves. No significant differences were found in controls for each prick-prick test for food with or without manipulation with latex gloves. Significant differences were found in the group of patients when performing prick-prick with the different foods before and after manipulation with latex gloves. The authors also observed that there were significant differences in prick-prick test between patients with latex sensitization and non-sensitised controls and that the results of prick-prick test varied for each patient depending on whether or not foods had been handled with latex gloves.
Implications	Confirms the importance of manipulating foods with vinyl gloves or other material containing no latex in order to avoid false results.

Study details	Schwartz, 1985[37]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing: uncontrolled longitudinal study
Aims/ Objectives	To report on experience with a photometric immunoassay to measure urinary cannabinoids (marijuana).
Description of study and methods	The participants were adolescents and young adults who had an abrupt and closely supervised cessation of drug use on entering a strict rehabilitation program. All participants, except one, were male. Participation in the study was voluntary. At the time of admission, participants completed a questionnaire about aspects of previous marijuana use. One or two directly supervised urine specimens were obtained on the day of admission and each day thereafter, until the testing detected no cannabinoids for two consecutive days. The analysis was performed using the EMIT-at Urine Cannabinoid Assay test. The study consisted of three parts. The first part determined the sensitivity and specificity of the EMIT-at assay by comparing the results with answers to the questionnaire on previous marijuana use. This part used data from all 70 participants enrolled in the rehabilitation programme. The second part involved the selection of 3 subgroups for more intensive, repeated urine testing: 5 males who were chronic, heavy users; 4 males who were moderate users; and 1 male and 1 female who were irregular and infrequent users. The third part was designed to determine whether streetwise marijuana users might be able to adulterate or dilute a urine specimen. Blood, bleach, vinegar, salt, and liquid soap were added to known cannabinoid-positive urine specimens and the testing was repeated.
Results (if applicable)	No falsely positive urine test results were found among 70 participants admitted consecutively to the programme. Among the 5 chronic users, urinary cannabinoids were detected for an average of 13 days (range 9 to 25 days), following cessation of use. Among the 4 moderate users, test results remained positive for an average of 4.7 days (range 2 to 8 days). Test results were negative 48 hours after cessation in the two irregular and infrequent users.
Implications	The specificity of the method for detecting recent marijuana use appears excellent; the sensitivity depends on the potency of the cannabis preparation, the time of last use, the frequency of previous use, and the specific gravity of the urine specimen. On the basis of this preliminary testing, positive test results for more than eight consecutive days suggest either surreptitious continued use or previous chronic, heavy use in a newly abstinent person. Purposeful adulteration of known-positive urine specimens, produced falsely negative results. It is therefore recommended by the authors that unless samples are collected under direct observation, urine colour, temperature, specific gravity, and dipstick tests for blood and pH should also be recorded.

Study details	Schwarzhoff, 1993[38]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	A battery of adulterating agents previously tested against radioimmunoassay (RIA) were evaluated in a similar format using fluorescence polarisation immunoassay (FPIA).
Description of study and methods	Sixteen different agents, at concentrations up to 10%, were tested against urine assays for cannabinoids, cocaine (metabolite), amphetamines, opiates, phencyclidine (PCP), and barbiturates. FPIA analysis was performed according to the manufacturer's recommendations. Samples were analysed in duplicate, one and seven days after preparation to simulate different collection/testing formats, and each run included unadulterated drug-negative controls (DNC) and unadulterated drug-positive controls (DPC), also at 150% of the cutoff. The potential to cause both false positive and false negative studies was evaluated. In selected cases, samples were analysed by gas chromatography/mass spectrometry (GC-MS) to determine if the treatment effect was caused by actual drug degradation.
Results (if applicable)	All six drug assays were susceptible to one or more adulterating agents, but the degree varied considerably between assays. The cannabinoid assay was most susceptible to adulterant-induced false negative results, and the barbiturate assay was most susceptible to false positive results. The remaining assays demonstrated relatively few, but characteristic effects, some of which were attributable to drug degradation and others to assay interference. Specifically, ascorbate, vinegar, bleach, lime solvent, and eye drops all caused false negative results when tested at 5%. Ascorbate was as effective at 1% as it was at 10%. Golden seal root produced significant effects in the THC and barbiturate assays at concentrations less than 1%.
Implications	The FPIA test is susceptible to specimen adulteration, but the susceptibility is unique to the particular chemical agent and to the specific drug test. Of the assays examined in this study, few demonstrated any tendency to produce false positive results. Several agents caused false negative results, and in most cases the negative tests were the result of assay interference, not drug degradation. Although the results of pH measurement on adulterated samples verified its utility in identifying some samples adultered with interfering agents, other adulterants that cause substantial effects would not be identified by pH measurements alone.

Study details	Stechova, 2002[39]
Country of publication	Czech Republic
Topic category	TES
Focus of research	Prevalence (extent of problem) study
Type of study or article	Survey: questionnaire (uncontrolled cohort)
Aims/ Objectives	To investigate non-compliance in diabetic patients treated by insulin pump.
Description of study and methods	The investigators used an anonymous questionnaire, that was designed to map out patients' non-compliance. Responses were obtained from 74 patients from a range of age groups. The study also included 3 case reports demonstrating different forms of non-compliance and showing therapeutic problems related to patients' non-compliance.
Results (if applicable)	In this study, 25% of patients confessed to occasional tampering with blood glucose test results (concealing of high blood glucose level or fabrication of results), 36% of patients sometimes applied non-controlled overdoses of insulin, and 33% of patients had never checked urine analysis. However, a majority of patients questioned preferred to continue this type of therapy and found insulin pump therapy satisfactory.
Implications	The results of the questionnaire confirm the authors' experience that non-compliance (at least occasional) is a relatively frequent phenomenon in type 1 diabetes patients.

Study details	Tsai, 1998[40]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory screening tests
Aims/ Objectives	To investigate the effect of high concentrations of nitrites on the detection of five commonly abused drugs by immunoassay screening and GC-MS analysis.
Description of study and methods	Drugs tested: cocaine metabolite (benzoylecgonine), morphine, THCCOOH, amphetamine, phencyclidine. Immunoassays evaluated: instrument-based Abuscreen ONLINE assays, on-site Abuscreen ONTRAK assays, one-step ONTRAK TESTCUP-5 assays. Multianalyte standards containing various levels of drugs were used to test the influence of both potassium and sodium nitrite.
Results (if applicable)	In the ONLINE immunoassays, the presence of up to 1.0M nitrite in the multianalyte standards had no significant effect for benzoylecgonine, morphine and phencyclidine assays. With a high concentration of nitrite, ONLINE became more sensitive for amphetamine and less sensitive for THCCOOH. No effects of nitrite were observed on the results of the Abuscreen ONTRAK assays or on the absolute qualitative results of the TESTCUP-5 when testing the nitrite-adulterated standards. However, the produced intensities of the signals that indicate the negative test results were slightly lowered in the THC and phencyclidine assays. Presence of 0.1M nitrite did not show dramatic interference with the GC-MS analysis of benzoylecgonine, morphine, amphetamine and phencyclidine. Nitrite ion significantly interfered with the detection of THCCOOH by GC-MS. The presence of 0.03M of nitrite ion resulted in significant loss in the recovery of THCCOOH and its internal standard by GC-MS.
Implications	The problem of nitrite adulteration could be alleviated by sodium bisulfite treatment even when the specimens were spiked with 1.0M of nitrite ion.

Study details	Tsai, 2000[41]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory tests: controlled study using samples
Aims/ Objectives	To investigate the influence of both urine sample matrix and the duration of nitrite exposure on nitrite interference of a cannabinoid (THCCOOH) detection.
Description of study and methods	Nitrite ion has been identified as the active ingredient of two commercial adulterants that could cause discrepant results between the immunoassay screening and gas chromatographic - mass spectrometric (GC-MS) confirmation of THCCOOH in urine. Procedures to chemically convert the nitrite ion at the beginning of sample preparation for GC-MS analysis may not overcome all nitrite adulteration cases because portions of the THCCOOH might have been lost between the time of sample collection and the time of analysis. Forty clinical 'THC-positive samples' that had been screened and confirmed positive for the presence of THCCOOH were spiked with 0.15M or 0.3M of nitrite. Levels of THCCOOH at various time intervals after spiking were monitored by instrument-based cannabinoids immunoassays (Syva EMIT d.a.u. or Roche Abuscreen ONLINE assays) and by an onsite THC immunoassay (Roche ONTRAK TESTSTIK).
Results (if applicable)	The two outstanding 'urine specimen factors' that dictated the effectiveness of the nitrite adulteration were urinary pH and the original drug concentration before nitrite spiking. Significant decreases in the immunoassay results could be observed within 4 h of nitrite treatment in the majority of samples with acidic urinary pH values. Regardless of their original concentration of THCCOOH all of the 20 samples that had acidic pH values gave negative immunoassay results 1 day after nitrite adulteration. The immunoassay results of samples with neutral or basic pH values were less affected by nitrite exposure in the same studies. Approximately 2/3 of the samples with pH values >7.0 remained immunoassay-positive 3 days after nitrite spiking. Some of the adulterated urine that showed no change in immunoassay results might exhibit significant decrease in GC-MS recoveries.
Implications	The decrease or loss of immunoassay detectable cannabinoid cross-reactives in acidic 'THC-positive samples' can be attenuated by chemically increasing the pH value of the samples to the basic pH range.

Study details	Uebel, 2002[42]
Country of publication	South Africa
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory screening tests
Aims/ Objectives	To investigate the influence of household chemicals used to adulterate test results of urine samples that tested positive for cannabis or methaqualone (Mandrax)
Description of study and methods	Assays were performed using Syva Emit drugs-of-abuse urine reagents on an ETS Plus Analyser. Urine tests for the presence of cannabis and methaqualone (Mandrax) were performed. The tests were done on drug-positive urine samples collected from patients. Seven household chemicals (4.95% mass per mass sodium hypochlorite; Dettol; 2% glutaraldehyde solution; 99% ethanol; liquid hand soap; and hydrogen peroxide) were added in four different concentrations (5%, 10%, 20% and 40% volume per volume) to the urine samples. Control urine samples were diluted with the same volume of drug-free urine as the volume of adulterant added to the test group. The samples with the added drug-free urine were pre-analysed to ensure that they still tested positive. Tests on the adulterated samples were done in triplicate and results were analysed statistically.
Results (if applicable)	Most of the chemicals tested influenced the outcome of positive toxicological screening results for these drugs. Glutaraldehyde and the liquid soap had the largest effect (false negative) on the methaqualone test. Dettol and liquid soap had the largest effect on the cannabis test. Higher concentrations of the adulterant were not always an indication of the extent of modification of the test result. The addition of certain chemicals (ethanol, isopropanol and peroxide) to the urine samples tested for methaqualone interfered with the test to such an extent that it gave invalid test results.
Implications	Hand soap, which is commonly available in most public toilets, gave false-negative results for both tests.

Study details	Urry, 1998[43]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory tests and literature review (non-systematic)
Aims/ Objectives	To identify all sources of nitrite in urine and the range of concentrations associated with these sources and to determine if nitrite adulteration can be supported based on a quantitative result.
Description of study and methods	Unlike many other adulterants, nitrite is found in normal urine at low concentrations. In order to defend a report of nitrite adulteration it is necessary to provide evidence that the amount of nitrite in a workplace urine specimen could not arise by normal means. The scientific literature was reviewed for internal and external sources of nitrite and their concentration ranges. The following specimens were obtained and nitrite concentrations measured by a spectrophotometric method: clinical specimens nitrite-positive by test strip; specimens culture-positive for nitrate-reducing microorganisms; specimens from patients on medications that may metabolise to nitrite; and drug test specimens, both negative and others that appeared to be adulterated with nitrite.
Results (if applicable)	The literature and the nitrite measurements of this study indicate a substantial difference from natural sources compared with adulteration.
Implications	A quantitative measurement of nitrite by a well-structured assay can provide scientifically valid and forensically defensible proof of adulteration with a nitrite-containing substance. A related paper presents a quantitative method for analysis of nitrite in urine.

Study details	Wu, 1999[44]
Country of publication	USA
Topic category	TES
Focus of research	Detection
Type of study or article	Laboratory testing: controlled study with samples
Aims/ Objectives	To examine the effect of pyridinium chlorochromate (PCC) found in the product 'Urine Luck'.
Description of study and methods	PCC was prepared and added to positive urine controls at concentrations of 1, 10, 50, and 100 g/L. The controls were assayed for methamphetamine, benzoylecgonine (BE), codeine and morphine, tetrahydrocannabinol (THC), and phencyclidine (PCP) with the EMIT II and Abuscreen Online immuno-assays, and by gas chromatography/mass spectrometry (GC/MS). Two tests were also developed to detect PCC in urine: a spot test to detect chromate ions using 10 g/L 1,5-diphenylcarbazide as the indicator, and a GC/MS assay for pyridine. Testing was performed on 150 samples submitted to routine urinalysis, compliance, and workplace drug testing for PCC, using these assays.
Results (if applicable)	Response rates decreased at 100 g/L PCC for all EMIT II drug assays and for the Abuscreen morphine and THC assays. In contrast, the Abuscreen amphetamine assay produced apparently higher results, and no effect was seen on the results for BE or PCP. The PCC did not affect the GC/MS recovery of methamphetamine, BE, PCP, or their deuterated internal standards, but decreased GC/MS recovery of the opiates at both intermediate (50 g/L) and high (100 g/L) PCC concentrations and apparent concentrations of THC and THC-d3 at all PCC concentrations. Two of the 50 samples submitted for workplace drug testing under chain-of-custody conditions were positive for PCC, whereas none of the remaining 100 specimens submitted for routine urinalysis or compliance drug testing were positive.
Implications	PCC is an effective adulterant for urine drug testing of THC and opiates. Identification of PCC use can be accomplished with use of a spot test for the oxidant.

TOPIC: RECORDS

Study details	Gwo-Jong, 2001[49]
Country of publication	Taiwan
Topic category	REC
Focus of research	Intervention
Type of study or article	Proposal and description of a technique
Aims/ Objectives	The authors propose a mean quantitisation based fragile watermarking approach that can be used to judge the credibility of a suspect image.
Description of study and methods	The approach embeds a watermark by taking the mean value of a set of wavelet coefficient. Through theoretical analysis of the probabilities of watermark errors caused by malicious tampering and incidental distortion, the best number of coefficients needed to embed a watermark at each scale can be computed so that the trade off between robustness and fragility can be optimised. Since the probability of watermark errors caused by incidental distortion at each scale is different, the detection responses at all scales should be integrated so as to obtain a global estimation of the maliciously attacked area. Then decision rules can be used to determine whether a suspect image has been tampered with or not. The paper describes the mean-quantitisation-based fragile-watermarking approach and presents an information-fusion technique that can be used to integrate the detection results at multiple scales.
Results (if applicable)	Experimental results demonstrate that the credibility of the method is superior to that of the conventional quantitisation based methods under malicious attack followed by an incidental modification, such as JPEG compression, sharpening or blurring.
Implications	This image authentication scheme is able to detect malicious tampering while tolerating some incidental distortions.

Study details	Lim, 1979[48]
Country of publication	USA
Topic category	REC
Focus of research	Detection
Type of study or article	Theoretical model
Aims/ Objectives	To present a methodology that yields the combinations of ways an adversary may disguise a special nuclear material (SNM) theft by tampering with the bookkeeping in a material accounting system.
Description of study and methods	A directed graph, or logic diagram is used to model the interactions of the accounting system and the adversary when he attempts to thwart it. The fundamental structures of the logic diagram that facilitate this modeling are the inhibit gate and the enable gate. Each gate has unique graphical and Boolean representation. A set of Boolean equations is derived from the logic diagram, where the dependent variable is successful SNM theft with no detection by the material accounting system within a specified time frame. Solving the set of equations for the prime implicants yields the various combinations of ways by which an adversary can tamper with the accounting system to disguise an SNM theft. A common-mode failure analysis of the prime implicants provides the collusion requirements (who and how many) needed to successfully tamper with the accounts and records. In addition, important adversary tampering acts are determined.
Results (if applicable)	No implementation in this report, therefore no results are reported.
Implications	The results of the above analyses would identify the weaknesses in the bookkeeping structure of the material accounting system and suggest possible modifications for 'hardening' those weaknesses.

Study details	Roudnitzky, 1982[50]
Country of publication	France
Topic category	REC
Focus of research	Risk assessment
Type of study or article	Discussion paper
Aims/ Objectives	Discusses security of data processing systems in hospitals
Description of study and methods	Discusses risks within different types of institutions, origins of risks, different types of risks and costs of effective safety programmes.
Results (if applicable)	Banks and financial divisions of companies were found to be most at risk. The vulnerable points were: physical access to the computer; manipulation of information during data-entry; and access to the information. It is estimated that an effective safety program within a hospital would cost up to 20% of the total hospital budget: 3% for equipment depreciation; 7% for materials and staff; 10% for operating costs (7% for maintenance and 3% for breakdown and insurance costs).
Implications	It is suggested that every hospital region should develop a safety chart containing the relevant principles and methods of safety management.

TOPIC: ORGANISATIONAL FACTORS

Study details	Ambrose, 2002[51]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To examine the relationship between injustice and workplace sabotage.
Description of study and methods	Drawing on the organisational justice and workplace deviance literatures, the authors hypothesise that injustice will be the most common cause of sabotage and that the source of injustice will influence the goal, target and severity of sabotage behaviour. Following this, the 132 first-person accounts of sabotage activities in a particular book served as data for the study. Three trained raters read the accounts, evaluated and coded each on four dimensions.
Results (if applicable)	The results generally support the authors' hypotheses. First, injustice was the most common cause of sabotage. Second, when the source of injustice was interactional, individuals were more likely to engage in retaliation, and when the source of injustice was distributive, individuals were more likely to engage in equity restoration. Third, the source of injustice and the target of sabotage were generally the same, although this relationship was stronger for organisational targets than for individual targets. Finally, there was an additive effect of distributive, procedural and interactional justice on the severity of sabotage.
Implications	Saboteurs are more likely to 'miss their mark' when they target individuals than when they target organisations. The research suggests that primary causes of sabotage are workplace phenomena that can be managed. Research on justice provides useful guidelines for increasing workplace fairness. Because powerlessness was the second most frequent cause of sabotage, research on empowerment may also provide a useful framework for managing sabotage. When the structure of procedures is unfair, individuals are as likely to perceive this as taking from them something they deserve (restoration) as they are to perceive themselves as being harmed (retaliation). The results suggest that saboteurs do not randomly engage in sabotage activities, but target their behaviour at the perceived source of the injustice.

Study details	Abbott 2001[65]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Literature review
Aims/ Objectives	To analyse employee knowledge about workplace factors that relate to employee job satisfaction, as well as the saliency of these facts for the individual.
Description of study and methods	Qualitative and quantitative analyses were performed to investigate the factors of interest: emotion; employee involvement, organisational justice/fairness; defensive behaviours; conflict/mediation/impression management; and employee feedback. The qualitative data were included for the purpose of determining suggestions for problem resolution in the case of defensive behaviours observed or participated in by workers.
Results (if applicable)	The authors state that it is clear that one may not be able to make accurate assumptions pertaining to how such variables as sex, age, race, education level, income level, or length of job tenure relate to the dependent variables of interest. The authors also state that continuing research needs to be done aimed at what forms of motivating employees to develop positive attiudes and to perform effectively, therefore, appears to be essential, if there is to be much hope of curbing workplace violence and anti-organisational behaviour as noted throughout this piece of research.
Implications	The information from this research could inform personnel managers and other supervisors as to the motivating factors for employees doing harm within the working environment.

Study details	Chen, 1992[52]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Questionnaire survey
Aims/ Objectives	To investigate, based on findings from the domain of organisational frustration, the conceptual similarity between stress and frustration and the functional similarity between frustrated events and work stressors, the relationships of behaviours (aggression, withdrawal, theft and substance use) with work stressors and affective reactions.
Description of study and methods	Four hundred (400) employees from 14 sources volunteered to participate. Almost all were white-collar employees who covered a wide range of occupations. Postal questionnaires were administered and 50.5% were returned. Five work stressors (role ambiguity, conflict, interpersonal conflict, situational constraints and workload) were measured using standard scales. Job satisfaction and feelings of frustration were also measured using standard scales. Another scale was used to measure how respondents felt at work for the past 30 days and a scale developed in the study was used to rate stress. Interpersonal aggression, sabotage, hostility and complaints, theft, substance use, absenteeism and intention to quit were also assessed.
Results (if applicable)	All stressors except workload were correlated with aggressive acts (sabotage, interpersonal aggression and hostility and complaints), theft and intention to quit. Workload was significantly but only modestly related to hostility and complaints and intention to quit. None of the stressors were related to substance use at work. Role ambiguity and situational constraints were significantly related to absenteeism but with small magnitude. Feelings of frustration and stress about jobs were significantly correlated with interpersonal aggression, hostility and complaints, and intention to quit. Anger and job satisfaction were significantly related to all behaviours except substance use at work. Substance use at work was correlated with sabotage, hostility and complaints, theft and intention to quit. Theft was correlated with all behaviours except absenteeism. Absenteeism was only slightly related to interpersonal aggression and hostility and complaints. All aggressive acts, intention to quit and theft were highly intercorrelated.
Implications	Authors state that their design makes it impossible to draw any causal inferences about the impact of stressful job conditions on behaviours. From a theoretical perspective, they speculate that work stressors may interfere with individuals' goal attainment or maintenance as frustrated events do. The interference can be frustrating or arousing to employees, making people irritable or annoyed, and triggering aggressive behaviours. If this speculation were true, results established in the frustration field should be of interest to researchers in the job stress domain.

Study details	Darwen, 2001[53]
Country of publication	Australia
Topic category	ORG
Focus of research	Causation
Type of study or article	Theoretical model
Aims/ Objectives	To demonstrate two mechanisms that sabotage the emergence of full mutual cooperation.
Description of study and methods	Uses the 'iterated prisoner's dilemma' to demonstrate why more choices cause less cooperation. Presents the two mechanisms mentioned in the objective: first, to increase cooperation requires behavioural (phenotypic) diversity to explore different possible outcomes, and once evolution has converged on a particular degree of cooperation, it is unlikely to shift. Secondly, more choices allows a richer choice of stable strategies that are not simply cooperating with each other to exclude an invader, but which are symbiotic. Such non-symmetric and symbiotic players in the space of strategies act as roadblocks on the path to full cooperation.
Results (if applicable)	None stated.
Implications	Unclear as to implications.

Study details	DiBattista, 1991[66]
Country of publication	USA
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Questionnaire: Delphi technique
Aims/ Objectives	To examine a list of sabotage forms found in the workplace today, develop reasons for the sabotage, and create methods for reducing the risk of sabotage events.
Description of study and methods	Forty-four human resources managers from ten companies located in Northeast America participated. The Delphi technique was employed in the construction of the sabotage forms questionnaire, the sabotage reasons questionnaire and the development of methods to counter sabotage events.
Results (if applicable)	Findings revealed that various forms of sabotage have subtly blended into the work routine: deliberate absenteeism, slowing down production, working without enthusiasm and consistent turnover.
Implications	The findings direct human resources managers to observe worker conflict and help reduce tension-causing situations between managers and employees. Strategies focus on implementing interpersonal approaches and organisational structure approaches to reduce the risk of sabotage.

Study details	DiBattista, 1996[67]
Country of publication	USA
Topic category	ORG
Focus of research	Intervention study
Type of study or article	Survey: Questionnaire
Aims/ Objectives	To present a method for sensing a crisis or a sabotage event and then manage the dilemma so that a full crisis is avoided.
Description of study and methods	A discussion of four stages of an event or crisis: 1) the prodromal (precrisis) stage; 2) the acute crisis stage; 3) the chronic crisis stage; and 4) the crisis resolution stage. The aim is to forecast the impact and the probability of an event. This is implemented in a study of 121 human resources managers representing small, medium and large companies located in the Northeast US in November 1993. Each manager received a questionnaire that required him/her to develop a Sabotage barometer and compute the Sabotage Impact Value and the Probability Index Factor. The managers were asked to scan a list of 30 potential sabotage events, to plot 10 of them and to present their intervention plans for each.
Results (if applicable)	The data showed that 79% of the respondents agreed that “a crisis in business today is as inevitable as death and taxes”, but fully 60% admitted that they do not have a prepared management intervention plan. And whether a company had ever experienced a sabotage act in the past was no indicator to whether it had a plan. Of significant importance to HRM professionals is the fact that those companies with a plan reported substantially shorter crisis durations (during the chronic crisis phase) than companies without a plan when they experienced an event (about 2.5 times shorter). The median length of the chronic crisis stage was seven months. Only 9% of the respondents showed evidence of managing an event from the precrisis stage directly to the final stage of the resolution.
Implications	Although recognition and deterrence procedures may be in place in some cases, sabotage acts are deemed to be premeditated. Thus, it is more important to determine who causes sabotage than what is sabotaged or why. In building a comprehensive intervention plan, management should continue to promote security awareness within its employer-employee relationships. This aspect of training will produce a significant payoff to the organisation compared to costs incurred in events that reach the acute and chronic states.

Study details	Giacalone, 1987[54]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Survey: questionnaire
Aims/ Objectives	Using the process of accounting as a basis, the present study investigated whether the a priori reasons a person has for the acceptability of sabotage will result in a greater likelihood that they will justify sabotage within an organisation. Specifically, the study investigated whether individuals who will accept more reasons for sabotage will justify sabotage more highly than those who do not.
Description of study and methods	The study enrolled 38 unionised labourers at a northeastern US electrical factory who volunteered their participation. A five-year employee of the plant who had recently resigned was asked to list the different methods that were used by the employees to sabotage the company. This generated a list of 29 general sabotage methods that fell into four global categories: 1) work slowdowns; 2) destruction of machinery, premises, or products; 3) dishonesty; and 4) causing chaos. The same ex-employee was asked to make a list of reasons justifying sabotage that employees gave when they heard of an act of employee sabotage. Participants were asked to complete a packet which contained the sabotage method and sabotage reason questionnaires. This was done anonymously. Questions were rated on a scale of 1 (not at all justifiable) to 7 (totally justifiable). Responses were summed across responses on the potential reasons for sabotage; median splits were performed on the potential reasons for sabotage, thereby creating two groups: high reason acceptors and low reason acceptors. Participants' responses to each of the sabotage methods within each of the four categories were also summed, thereby creating four general indices of general sabotage methods.
Results (if applicable)	High reason acceptors justified production slowdowns more than low reason acceptors. Similarly, high reason acceptors justified destruction of machinery, premises, or products more than low reason acceptors. Unexpectedly, high reason acceptors did not significantly justify dishonesty more than low reason acceptors. Finally, high reason acceptors justified causing chaos significantly more than low reason acceptors.
Implications	The present study provides for a variety of future investigations which should help to clarify the role of self-preservation in sabotage. Specifically, the authors propose an emphasis on two areas: the relationship between sabotage justifiability and actual sabotage, and the role of individual differences in sabotage propensity. It is the authors' opinion that particular importance ought to be placed on developing those investigations which help management to recognize and deter the saboteur and his costly acts, as opposed to studies dealing with the genesis of the problem.

Study details	Giesberg, 2001[68]
Country of publication	USA
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Survey and literature review
Aims/ Objectives	To use evidence from prior studies and field interviews to develop an effective focus and a full understanding of corporate sabotage.
Description of study and methods	The author incorporated a hybrid of multidimensional scaling, combining this technique with the analysis of historical data. Field interviews were also conducted to evaluate a divergent group of participants representing major corporations within the New York/New Jersey metropolitan area. Through deductive analysis the findings were extrapolated to describe workplace sabotage and to better acquaint employers with effective means of preventing violent behaviours among individual workers. Participants were employees from four independent organisations representing both the public and private sectors. Pre-designed questions were administered to participants at their place of work. Raw scores from the interviews were converted into percentages and used in the deductive analyses.
Results (if applicable)	Workplace violence was not distributed randomly across all workplaces, but was clustered in particular occupational settings. More than half (56.1%) of workplace violence occurs in the private sector, including retail trade and service industries. In this study, 70% (n=7) from the private sector were of the perception that the propensity for workplace violence exists in the private sector, while 40% (n=4) of the public-sector employees agreed with that perception. Among the public-sector employees, 60% (n=6) were of the opinion that a lack of communication was the principal cause of workplace violence, while 40% (n=4) believed that causes other than a lack of communication were the culprit. In both the private and public sectors of employment 8 employees agreed by an 80% margin that better communication by management can prevent the proliferation of workplace violence. The remaining 2 employees, who represent 20% in both sectors of employment, agree that other means exist for preventing violence in the workplace.
Implications	It can be concluded that employees of both public and private sectors have a better grasp of which sector has a propensity for committing workplace violence. Not only are the employees from the various sectors cognisant of the causes of workplace violence, they are also aware of how to prevent it. This was a very large topic with sweeping conclusions based on a survey of only 20 participants in the USA.

Study details	Gillespie 1995[69]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Content analysis of business communications.
Aims/ Objectives	To investigate the impact of organisational-level variables on individual decisions.
Description of study and methods	The research used a modified version of Lawrence Kohlberg's method of qualitative content analysis to analyse public communications of four companies which had experienced a public ethical controversy.
Results (if applicable)	Corporate documents do contain moral reasoning content; in most instances results using organisations as subjects: stages of moral reasoning used varies according to situation (real or hypothetical) and sometimes according to the nature of the harm. Limitations exist primarily because of the specificity with which Kohlberg's system was devised.
Implications	This may have implications in analysing NHS policy documents or reports on the prevention or investigation of sabotage and/or tampering in the UK setting.

Study details	Graham, 1993[55]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Observational study
Aims/ Objectives	To identify patterns of behaviour that reflect the relationship among workers and between workers and management in their day-to-day work experience.
Description of study and methods	The research focused on the work experience of a hidden observer in a single Japanese automobile plant from July 1989 to January 1990. The analysis is based on extensive field notes and on formal documents distributed by the company. The paper discusses seven identified components within a Japanese management structure. Each of the seven components is examined in relation to worker compliance and resistance.
Results (if applicable)	In general, it was only through collective action that workers were able to affect any balance in control on the shop floor. The author divided worker response into two areas: compliance and resistance and the two areas were connected to each of the seven components of the management scheme. Five components addressed controlling the social aspects of production (pre-employment selection process; orientation and training for new workers; the team concept; a philosophy of kaizen; and attempts at shaping shop floor culture) and two addressed the technical aspects of production (the computerised assembly line; and just-in-time production).
Implications	Data collected from this case study do not support the contention that the participation scheme found in modern Japanese management increases worker control. This was true technically and politically. The research raises the question of whether the existence of formal structures is a reliable measure for determining the successfulness of intraorganisational transference, particularly when a distinctive feature of that organisation is employee commitment, identification, and loyalty.

Study details	Harris, 2002[56]
Country of publication	UK
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Literature review
Aims/ Objectives	To explore, describe, and classify the deviant and counterproductive actions of frontline, customer-contact service providers, and also model the antecedents and consequences of such actions.
Description of study and methods	Existing studies and field interviews (n = 182) were used to forward the notion of "service sabotage", denoting organisational member behaviours that are intentionally designed negatively to affect service. The interviews were conducted in four organisations in the hospitality industry (two hotel and restaurant chains and two solely restaurant chains). A broad range of employees were interviewed.
Results (if applicable)	The study found that 85% of interviewed frontline, customer-contact employees had sabotaged service within the 7 days preceding the interview. Evidence emerged that indicated that coworkers (and in some cases managers) are involved or tacitly approve service sabotage actions. Data reveal that more than 90% of all informants accept that service sabotage is an everyday occurrence in their organisation. A typology of service sabotage behaviours is forwarded in this report and a range of antecedents and consequences are explored.
Implications	The study revealed that frontline service sabotage behaviour affects performance and also has a number of psychological and emotional consequences for the employee. The authors attempted to construct a theory from this work and the next stage of theory testing is left for future studies.

Study details	Klein, 1996[57]
Country of publication	USA
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To investigate employee destruction of organisational products or property.
Description of study and methods	Review of literature to formulate a classification model for sabotage. The authors extrapolate from organisational concepts as a starting point and include published accounts of acts of sabotage.
Results (if applicable)	The review covers areas of job design, skill variety, task autonomy, equity, organisational commitment, job satisfaction, social information processing and other factors as organisational attributes that can lead to employee sabotage.
Implications	The authors have only introduced organisation behaviour concepts that may be helpful in the evaluation of workplace sabotage. A thorough evaluation of workplace sabotage needs the expertise of both the mental health professional skilled in the evaluation of individual psychopathology and the consultant knowledgeable in organisational behaviour. A team approach to this problem of workplace property violence may be optimal to attain a satisfactory biopsychosocial evaluation and subsequently prevent or reduce sabotage in the workplace.

Study details	Marakas, 1996[58]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To focus attention on a form of covert resistance to the IT implementation process that is neither couched in criminal intent nor motivated by personal gain.
Description of study and methods	The authors define passive resistance misuse (PRM) to be a recalcitrant, covert behaviour that results from both fear and stress stemming from the intrusion of the technology into the previously stable world of the user. Such behaviour takes the form of overt cooperation and acceptance of the proposed system combined with covert resistance and likely sabotage of the implementation effort.
Results (if applicable)	The authors offer two related theoretical foundations to assist in explaining the phenomenon of PRM: 1) passive-aggressive behaviour theory; and 2) action science's espoused theories versus theories in use. Through those two theoretical lenses the authors describe PRM, provide examples of PRM behaviour as well as its proposed causes and offer a framework for inclusion of this construct into an information system (IS) design and implementation research agenda.
Implications	The authors argue that the necessary interpersonal competence for successful IS implementation must allow for less rational displays of resistance, such as PRM, than have been previously acknowledged. By recognising the potential for PRM behaviour we may be more able to create an atmosphere in which people become less inhibited to voice these expressions of fear.

Study details	Motowildo, 1977[59]
Country of publication	Canada
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Development of rating scales
Aims/ Objectives	To determine the feasibility of extending scaled-expectations methodology into the realm of morale measurement, to develop systematic procedures for assessing group morale without unduly restricting the measuring instrument to any of the several definitions that appear in the literature.
Description of study and methods	The scale development strategy was to obtain examples of expressions of morale, to develop categories based on their behaviour content and to develop a behavioural rating scale for each category. Around 190 military personnel in the US and two other locations participated in workshops. A final set of 8 behavioural morale categories was defined. The scales were then field tested in one of the non-US locations.
Results (if applicable)	Although errors of leniency and restriction of range did not seem severe, the ratings did show indications of halo error and only low to moderate interrater reliability. Despite these psychometric deficiencies, correlations with ratings of unit effectiveness and self-reports of unit members provided some evidence for convergent validity. Military units rated high on the morale scales were also rated high on overall effectiveness and low on frequency of low morale activities like dissent, drug abuse, and destruction/ sabotage. Members of units rated high on some of the morale scales were more likely to report high morale and intentions of reenlisting.
Implications	These results lend some support for the notion that group morale can be measured by means other than self-report indices. Behavioural-scaling methodology, which has been used in the past primarily to assess job performance, shows promise as an approach for measuring group morale. This methodology should be further explored as an alternative to self-report measures in other organisational contexts besides the military.

Study details	Sieh, 1987[60]
Country of publication	USA
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Interviews and qualitative analysis
Aims/ Objectives	To discover the rules, plans, conventions, images and so forth that people use to guide their behaviour (with regard to injustice and sabotage at work)
Description of study and methods	The study examined the episodes involving the employee's perception that he or she was treated unfairly at work. Social behaviour is explained through the collection and analysis of participants' accounts. The informants in this study were garment workers. Sixteen retired garment workers were interviewed. The research plan involved conducting semi-structured interviews with self-selected informants.
Results (if applicable)	Neither employee theft nor other forms of deviance were often selected when responding to matters involving inequity. In only a few cases was there any indication that theft occurred as a result of the worker feeling he or she did not receive what was owed to him or her. This can be explained by the influence of the work group and the institutional mechanisms developed by the union.
Implications	Inequity at work led in most cases to workers approaching the union or filing a complaint, rather than to sabotage or theft.

Study details	Spector, 1975[61]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Questionnaire
Aims/ Objectives	To: a) measure frustration in an organisational setting, and b) examine some correlates of that frustration. It was hypothesised that greater frustration experienced by an employee on the job would be associated with more reports from the employee of performing potentially detrimental behaviours such as complaining or sabotage.
Description of study and methods	Participants were either members of the staff of a Southern mental health facility (n=71), or persons known to the author who were employed in various organisations. Questionnaires were mailed to 136 persons and 82 (60%) were returned. Each person was given a packet containing two questionnaires, instructions and a cover letter. The first questionnaire was a six-choice Likert-format Organisational Frustration questionnaire. The second was a 35-item questionnaire asking the participant to indicate how often he or she had performed each of a number of behaviours listed. A factor analysis of the responses was performed to ascertain any underlying dimensions or factors of responses to frustration.
Results (if applicable)	The factor analysis of items on the response-to-frustration questionnaire yielded 10 factors with corresponding eigenvalues greater than 1.0. Of these, six were readily interpretable and were correlated with the total scores by these same subjects on the Organisational Frustration questionnaire: a) aggression against others (r = 0.26); b) sabotage (r=0.35); c) wasting of time and materials (r=0.22); d) interpersonal hostility and complaining (r=0.70); e) interpersonal aggression (r=0.22); and f) apathy about the job (r=0.29). When each respondent's total score on the Organisational Frustration questionnaire was correlated with each of the 35 items of the response-to-frustration questionnaire it was found that 19 of the 35 correlations were sufficiently large (r>0.23) to reach significance at the 0.05 level.
Implications	The authors state that although the current study was correlational and based on self-report data, it supports the contention that frustration in an organisational setting can have extremely negative effects on the behaviour of persons in that organisation. To the extent that considering quitting and actually quitting a job are related, frustration would be related to turnover. In addition, the complaints and hostility expressed by employees would adversely affect the organisational climate. Frustration was also found to be related to sabotage.

Study details	Storms, 1987[62]
Country of publication	USA
Topic category	ORG
Focus of research	Causation
Type of study or article	Survey: questionnaire
Aims/ Objectives	To examine the influence of organisational frustration and locus of control on emotional and behavioural reactions to frustrating conditions.
Description of study and methods	A questionnaire was administered to 160 employees from all levels of a community mental health facility. The mean age of participants was 35.2 years, and the sample was comprised of both men and women. Supervisory and non-supervisory positions were equally represented and participation was voluntary and confidential. Questionnaire packets were distributed through the head secretary of each of 16 departments. Of 330 questionnaires sent out, 160 were returned (response rate 48%). Each packet contained questionnaires on situational constraints (the Job Effectiveness Survey) with 37 items covering 14 areas of constraints; locus of control (Work Locus of Control Scale); and reactions to frustration (the Job Reactions Survey) a 29-item rating scale. Zero-order correlations were used to test the first two hypotheses, as they predicted simple relationships between pairs of variables. The third hypothesis required tests for moderator effects. The sample was trichotomised by locus of control and correlations were calculated for each subgroup. Corresponding correlation triplets were compared statistically with chi-squares. Moderated regression analyses were also conducted.
Results (if applicable)	First hypothesis: the variable situational constraints (a measure of organisational frustration) was positively related to perceived frustration ($r=0.55$, $p<0.001$). Second hypothesis: the variable perceived frustration was positively related to behavioural reactions ($r=0.40$, $p<0.001$). The correlations for each dimension of the behavioural reactions measure with perceived frustration were all significant. Third hypothesis: the sample was divided into 3 groups based on locus of control and calculations made for each of the 3 groups. Chi-square statistics indicated significant differences among each set of three coefficients for five of six comparisons. Correlations were highest for high-scoring (external) subjects, and lowest for low-scoring (internal) subjects. Moderated regression analyses: A significant moderator effect, reflected in the significance of the product term, occurred for only one of the six comparisons, namely sabotage. Overall, behaviour reactions did not quite reach the normally accepted levels of statistical significance.
Implications	The organisation used in this study provided human services, and one might expect a low level of some aggressive types of behaviour. The reactions data were collected through self-report measures so there may have been under-reporting since some respondents may not have reported acts of sabotage, vandalism or theft. The authors state that support for the organisational frustration-behavioural reaction relationship is quite clear: frustrating work conditions can lead to counterproductive behavioural responses. See also Spector, 1995.

Study details	Thompson, 1993[63]
Country of publication	USA
Topic category	ORG
Focus of research	Prevalence (extent of problem) study
Type of study or article	Observational study
Aims/ Objectives	To analyse how workers interact with one another on the job, how they cope with the strains of the work, how they maintain a sense of self-worth, and how they develop and maintain informal norms with regard to customer spending.
Description of study and methods	The author spent approximately 9 weeks observing workers on an assembly line in the slaughter division of a large beef processing plant in the Midwest (United States). The workers did not know that the author was conducting research. The author worked along side the regular workers doing the same work. Couched within a symbolic interactionist perspective, the author focuses on the day-to-day activities of the assembly line workers. The author examined the sociological aspects of the workers' interaction on the job, how they coped with the danger, strain and monotony of the work, and how they developed consumer spending norms which virtually trapped them at the plant. The author also examined how workers attempted to maintain their sense of self-worth despite the demeaning and dehumanising aspects of their jobs.
Results (if applicable)	Results gained from the study were: 1) there was a subtle sense of unity among the line workers; 2) there were various coping mechanisms employed by workers in the dehumanising environment used in order to retain their sense of humanity and self-worth; and 3) there were consumer spending patterns among the line workers that seemed to "seal their fate" and make leaving the beef plant almost impossible.
Implications	Although sabotage did not seem to be a major problem at the beef plant, it did exist, and there appeared to be several norms (both formal and informal) concerning what was acceptable and what was not. Working at the beef plant was "dirty work". It was monotonous, difficult, dangerous, and demeaning. Despite this, the workers at the beef plant worked hard to fulfil employer expectations in order to obtain financial rewards. Through a variety of symbolic techniques, they managed to overcome the many negative aspects of their work and maintain a sense of self-respect about how they earned their living.

Study details	Tucker, 1993[64]
Country of publication	USA
Topic category	ORG
Focus of research	Intervention study
Type of study or article	Survey
Aims/ Objectives	To examine how employees pursue grievances against their employers, and in particular, temporary employees.
Description of study and methods	Data were collected from 277 students enrolled in an undergraduate sociology course at a state university in the southeastern United States. The participants were employed in a variety of short-term positions in a range of retail, restaurant, office or hospital settings. The participants provided a self-report of an employment experience prior to or while attending college. Individuals described their job, their company, other employees in their position, and any formal and informal means by which employees voiced complaints. They also discussed in detail a specific grievance they had with the organisation, including the source of the problem, their reaction, the extent to which others were involved, the length of the disagreement, and the resolution, if any.
Results (if applicable)	Employees in this study tended to pursue justice in a non-confrontational fashion. When an individual turns to others for assistance in the handling of a grievance, the conflict usually dissipates rather than escalates. When an employee confronts management, he or she is usually unsuccessful in getting the problem resolved, but rarely pursues the matter further. In summary, the strategies of conflict management used by temporary employees reflect the relationships they have with their employers and co-workers. They tend to respond to grievances by doing nothing or departing.
Implications	Despite its apparent economic benefits, temporary employment may ultimately reduce organisational efficiency by creating conditions that stifle active expressions of employee resistance.

TOPIC: TAMPER EVIDENT PACKAGING

Study details	Department of Trade and Industry, 1999[71]
Country of publication	UK
Topic category	TEP
Focus of research	Intervention study
Type of study or article	Non-systematic ('technological') review
Aims/ Objectives	To review available child-resistant closures and tamper-evident devices, and to look at their penetration in the market place and issues related to their production and use.
Description of study and methods	The review reports on regulations relating to child resistant closures (CRCs), types of CRCs, types of tamper evident packaging, penetration in the marketplace, developments in tamper evident packaging and CRCs, technical issues and conclusions.
Results (if applicable)	There do not appear to be major technical issues with the current tamper evident packaging and CRCs, and from searching the current literature, ideas for alternative and modified closure designs appear fairly frequently. Legislation defining the use of CRCs deals with the most serious hazards, and as such to a minority of products. However, although only a small percentage of household and garden products are fitted with tamper evident closures, an increasing percentage have CRCs. The main decision points for industry to voluntarily use CRCs would appear to be: cost; a desire to be responsible in terms of consumer safety; a requirement by a third party in the supply chain (e.g. a supermarket); and the level of safety consumers might reasonably expect is to have a CRC fitted. The additional cost of fitting the simplest one-piece CRC compared to a plain closure is relatively small but a two-piece CRC would have a greater on-cost. It is believed that many of the proposed new tamper evident and CRC closures have not been taken up by industry because of their higher costs.
Implications	The somewhat arbitrary nature of decisions of whether or not to fit a CRC could be rationalised by Codes of Practice advocating the use of CRCs on all household and garden chemicals packs which are labelled harmful, irritant, or where a statement is included that medical advice should be obtained if the product is swallowed.

Study details	Lockhart, 1997[72]
Country of publication	USA
Topic category	TEP
Focus of research	Intervention study
Type of study or article	Discussion paper/ equipment evaluation by uncontrolled trials.
Aims/ Objectives	To describe measurement and statistical treatment of the successes and failures of people to detect tampering and suggest ways to increase the success rate for detections.
Description of study and methods	Examples of failure modes are given. The current regulatory status of tamper evidence in the U.S. is discussed. Reports the results of a consumer survey by Packaging magazine and 'our surveys'. A series of measurements of tamper detection were made by researchers at the School of Packaging over the years 1983-1991. Twelve tamper-resistant technologies were presented to 1500 consumers at different times and in different places.
Results (if applicable)	The Packaging magazine survey indicates that consumers believe that tamper evident packaging is important and desirable to have on drug, food and personal care products. They believe that they do look at packages to detect tampering and many of them think they detect tampered packages. In spite of the value they place on tamper evident packaging they are not willing to pay very much extra to have it. 30% of respondents said they would not pay anything extra to have the tamper evident feature on packages. The author's surveys show that consumers do not detect tampering very well and probably do not look at the packaging as often or as closely as they say they do. Even if they did, the best success rate for the detection of tampering would be about 75% with many packages no more than 25 or 30% successful. These figures are for consumers who have been sensitised to look for tampering. When the consumer has not been alerted to the possibility of tampering, detection drops to 10% or less. Results of the experiment of 1500 people are reported.
Implications	Four elements comprise a programme for achieving effective tamper evidence: package design, specification, consumer education and performance evaluation. The design must be based on a realistic assessment of what the consumer can and will do to participate in the detection process. There must then be proper specification of the design so that it is correctly made. There is a description of performance evaluation. The author notes that statements on the packaging informing the consumer what the tamper evident feature is must be legible. Requirements for tamper evident packages which have not been presented until now are: consumer education; packages that are easy for consumers to diagnose; limited variety of systems; reduce rate of packing change; and better instructions for use. Not very clear where these results came from.

Study details	Paine, 1989[73]
Country of publication	UK
Topic category	TEP
Focus of research	Intervention study
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	Objective appears to be to review the literature on tamper-evident and tamper-resistant packaging.
Description of study and methods	A detailed study (no further details) of the published literature from January 1986 to 1989 was undertaken, supplemented by selected references to pilfering and tampering prior to January 1986. The period January 1982 to October 1983, covering nine months or so either side of the date of the Tylenol incident, is particularly significant in this respect. The report discusses: definitions of tamper-proof, tamper-resistant or tamper-evident packaging; statistics and marketing views; problems (reasons for pilfering and tampering, discouraging the tamperer, product areas and differences between them, relation to child resistant packaging, recall procedures and costs, legislation, consumer education), current tamper evident methods and future developments and innovations.
Results (if applicable)	No results as such: discussion of papers.
Implications	The literature indicates that one of the growth areas for development in the future will be in the area of security packaging including tamper evidence, especially for food. This will be reinforced by the expansion of original pack dispensing and over the counter sale of drugs and medicines, and the extension of security packaging in the food, cosmetics, toiletries and household goods fields, the last three being possibly prompted by legislation on child resistant packaging requirements and product liability. As far as drugs and medicines are concerned the present guidelines in a number of countries may well be raised to a mandatory level but in the food distribution field legislation does not at the moment seem likely. Voluntary codes of practice or guidelines will probably be introduced in some countries which at present have none.

TOPIC: FOOD

Study details	Antolovich, 2001[74]
Country of publication	Australia
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To determine the authenticity of commercial Australian orange juices using stable carbon isotope ratio analysis (SCIRA)
Description of study and methods	Thirty-five (35) samples of Valencia and 8 samples of Navel juices of known origin were used to establish a decision level before analysis.
Results (if applicable)	No significant seasonal variations in 13C/12C ratio were observed. Variations in combustion temperature in the method were also found to be insignificant.
Implications	SCIRA is a powerful method for determining adulteration by C4 sugars in fruit juices. These studies indicate that seasonal changes and instrumental operating conditions have little effect on the data. There does however seen to be a variation due to measuring technique and so it is important to carefully calibrate the system based on a large number of known samples to confidently analyse unknown samples.

Study details	Charbonneau, 1988[75]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	Using scanning electron microscopy and X-ray microanalysis to investigate three typical corrosion problems found in plain tinplate cans and to examine glass and glass-like particles that were found in canned foods.
Description of study and methods	Tinplate, glass and glass-like particles were studied using SEM and X-ray analysis. A quantitative SEM- X ray analysis method was used to measure the composition of glass particles in two alleged product tampering cases involving canned food.
Results (if applicable)	Through SEM and X-ray analysis it was determined that sulfate containing particles from the cannery cooling water reacted with exposed iron or tin-iron alloy on the tinplate surface causing an external rusting problem; sulphur dioxide was responsible for a container discolouration and a pitting corrosion problem in canned fruit nectar; hydrogen sulphide produced from the SO2-tinplate reaction was the cause of an associated off-odour problem; copper, possibly from a side seam welding operation, excessive headspace oxygen and a beading effect on the container body wall helped explain a detinning and pitting corrosion problem in canned fried apples. The details of the investigations of possible product tampering by the food companies are confidential! 'It may have turned out that the source of the glass was accidental contamination rather than product tampering'.
Implications	SEM-X ray analysis is a useful technique to examine extraneous materials in food like glass that may arise from chemical and physical changes in the food product.

Study details	Cordella, 2002[76]
Country of publication	France
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To use differential scanning calorimetry (DSC) to study the thermal behaviour of authentic honeys (Lavandula, Robinia, and Fir honeys) and industrial sugar syrups.
Description of study and methods	The effect of adulteration of honey with different amounts of syrup (5, 10, 20, 40 and 60%) were investigated. Thermal or thermochemical parameters such as the glass transition temperature (Tg), enthalpies of fusion, and heat capacity variation were measured.
Results (if applicable)	The syrups and honeys showed significant differences in thermal phenomena, as well as in their amplitude and position on the temperature scale. Results showed good reproducibility of the method for all samples studied. A linear relationship was found between the percentage of added syrup and the glass transition temperature. A similar relationship was obtained from the enthalpy of fusion results in the temperature range of 40-90 degrees C.
Implications	Under applied conditions, the effects of adulteration of honeys by industrial syrups appeared to be detectable from a level as low as 5%.

Study details	Downey, 2002[77]
Country of publication	Ireland
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory testing: controlled study with samples
Aims/ Objectives	To detect and quantify sunflower oil adulteration in extra virgin olive oils from the Eastern Mediterranean by visible and near-infrared spectroscopy.
Description of study and methods	Visible and near-infrared transflectance spectroscopy was used to analyse 138 oil samples. These comprised 46 pure extra virgin olive oils and the same oils adulterated with 1% (w/w) and 5% (w/w) sunflower oil. A number of multivariate mathematical approaches were investigated to detect and quantify the sunflower oil adulterant. These included hierarchical cluster analysis, soft independent modelling of class analogy (SIMCA method), and partial least squares regression (PLS). A number of wavelength ranges and data pre-treatments were explored. The accuracy of these mathematical models was compared, and the most successful models were identified.
Results (if applicable)	Complete classification accuracy was achieved using 1st derivative spectral data in the 400-2498 nm range. Prediction of adulterant content was possible with a standard error equal to 0.8% using 1st derivative data between 1100 and 2498 nm. Spectral and chemical literature were studied to isolate the structural basis for these models.
Implications	The authors state that this work has only included a single sunflower oil sample. Natural variations in chemical composition between samples of this oil will occur, for example, between varieties, harvest, and geographic locations. Therefore, the results reported in this work require extension to a greater number of sunflower and olive oil samples before they can be completely endorsed. The level of accuracy in this study is suitable for industrial use.

Study details	Eiesle, 1996[78]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To evaluate the analytical performance characteristics of the chiral LC method in a multilaboratory environment and to determine the inter-laboratory variability of the method.
Description of study and methods	Eleven laboratories collaboratively studied a liquid chromatographic (LC) method for determination of D-malic acid in apple juice. The mobile phase consisted of 16mM L-valine and 8 mM copper acetate adjusted to pH 5.5 with NaOH. The UV detector was set at 330 nm and a single reversed-phase LC column was used. Seven paired samples containing various amounts of D-malic acid ranging from 0 to 188 mg/100 mL of 12 Brix pasteurised apple juice were tested by each collaborator.
Results (if applicable)	Repeatability and reproducibility coefficients of variation ranged from 1.0 to 3.5% and 7.7 to 11.7% respectively, within the range of 26 to 188 mg D-malic acid/ 100 ml of 12 Brix apple juice.
Implications	The collaborative study results demonstrated that the method could quantitate the economic adulteration of apple juice with DL-malic acid at lower levels than those reported with previous methods. The LC method for determination of D-malic acid in apple juice has been adopted first action by AOAC International.

Study details	Elkins, 1994[79]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	laboratory tests
Aims/ Objectives	To determine the interlaboratory variability of this method of detecting adulteration in apple juice, by collaborative study.
Description of study and methods	L-Malic acid is the predominant acid in pure apple juice and no D-malic acid should be present. Synthetic malic acid contains 50% D-malic acid, is inexpensive and can be used to create nonauthentic apple juice. L-malic acid/ total malic acid ratios of 0.9 or less are indicative of a nonauthentic sample. Fourteen laboratories participated in a collaborative study to determine the L-malic/ total malic acid ratio in apple juice. Ten samples of apple juice were sent to each laboratory.
Results (if applicable)	Authenticity of the samples varied from 0 to 100%. The coefficients of variation in all cases were acceptable (about 5%). The method was adopted first action by AOAC International.
Implications	The method can be used to detect nonauthentic apple juice at the concentration of at least 30%. Not very relevant to the NHS.

Study details	Kannan, 1997[80]
Country of publication	India
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To perform analyses to detect menthol in branded and non-branded samples of Pan Masala by a simple spectrophotometric process.
Description of study and methods	The Prevention of Food Adulteration Act in India has stated that the limit of menthol addition to Pan Masala should not exceed 0.1% (1mg/g). The estimation of menthol in Pan Masala samples involves steam distillation followed by reaction with p-dimethyl amino benzaldehyde (DMAB) in acidic medium to give a red colour which is read at 550nm with the spectrophotometer. The sensitivity of this procedure is 75microg menthol per g sample.
Results (if applicable)	Using this method, 130 branded and 53 non-branded samples of Pan Masala were analysed for menthol content. Almost 25% of branded samples contained less than 1mg menthol per g Pan Masala. Non-branded Pan Masala contained 1mg menthol per g in 7.6% of samples. However, 92% of samples contained 1.1 to 6.5 mg menthol per g.
Implications	The results suggest that the addition of menthol is relatively higher in non-branded Pan Masala samples than in branded ones. Good manufacturing practice should be adopted so that the Pan Masala samples do not exceed 0.1% menthol concentration. Study is of questionable relevance.

Study details	Lambert, 1997[81]
Country of publication	USA
Topic category	FOD
Focus of research	Risk assessment
Type of study or article	Theoretical model
Aims/ Objectives	To suggest the use of probabilistic risk assessment to assess the threat of wilful tampering to public water systems.
Description of study and methods	The scope of the problem is described by classifying a variety of water systems, their components and functions, and some methods of wilful tampering with the systems. Event trees are shown to explain the progression of mitigating events that follow a tampering incident.
Results (if applicable)	Fault trees and other probabilistic models can be useful to explain the performance of individual mitigating systems. A probabilistic description of the potential consequences of an incident can be developed.
Implications	Such a quantitative risk assessment is useful to inform decision makers on how best to harden the systems against potential tampering.

Study details	Look 1993[90]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Equipment or process evaluation
Aims/ Objectives	To determine the level of food tampering awareness and opinions of foodservice managers in commercial and non-commercial foodservice facilities and to obtain descriptive information about the foodservice managers and their facilities. A second objective was to explore if a food tampering risk reduction educational programme based on principles of the Hazard Analysis Critical Control Point (HACCP) system was effective for self-instructional use by managers of foodservice facilities.
Description of study and methods	The study used descriptive and experimental research techniques. There were two phases to the investigation: phase 1 developed a questionnaire and phase 2 developed a workbook and an assessment form. The pre-and post test data from both phases was compiled and analysed.
Results (if applicable)	The results of the study provided information concerning the foodservice managers' current levels of awareness and concern towards food tampering and their willingness to take steps to help minimise food tampering hazards associated with self-serve foods in their operations. Findings indicated that increased awareness resulted in increased concern for food tampering. Therefore, by communicating food tampering risk reduction information to foodservice managers, they may become more aware of the potential and be receptive to making operational changes to reduce the risk.
Implications	The author states that the results of this study can be applied in education and practice in the foodservice industry. It is unclear how these results would apply in the NHS.

Study details	Nagarajan, 1967[82]
Country of publication	India
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To develop a simple technique for the detection of adulteration of flour with Lathyrus sativus, based on the detection of the amino acid BOAA which is characteristically present in L sativus seed but not in the seeds of other legumes commonly consumed as food in India.
Description of study and methods	One gramme of the powdered sample under test was extracted, filtered and used for subsequent analysis by paper chromatography or electrophoresis. The sensitivity of the method was investigated in an experimental trial. A pure sample of Bengal gram flour was mixed with L. sativus flour at levels ranging from 5-50% of the latter flour.
Results (if applicable)	In the experimental trial, chromatographic screening of the preparations revealed the presence of L. sativus at a level of 5% in the mixture. The specificity of the method was also evaluated by comparing it with another method. The latter method was not entirely specific for the detection of L. sativus alone, but other pulses also gave a positive test.
Implications	It is felt that the technique detailed here will prove to be of greater use in routine work on adulteration in many public health laboratories in view of its specificity for the detection of L. sativus present as seed or flour in a raw or cooked state. On the basis of preliminary trials, the Society of Public Analysts (India, 1967) has found this technique to be useful.

Study details	Ogrinc, 2001[83]
Country of publication	Slovenia
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory testing
Aims/ Objectives	To determine the authenticity, regional origin, and vintage of Slovenian wines using a combination of IRMS and SNIF-NMR analyses.
Description of study and methods	A total of 102 grape samples of selected wines were carefully collected in three different wine-growing regions of Slovenia in 1996, 1997, and 1998. The stable isotope data were evaluated using principal component analysis (PCA) and linear discriminant analysis (LDA).
Results (if applicable)	It was found that the resulting values are modified by the meteorological events during grape ripening and harvest.
Implications	The usefulness of isotopic parameters for detecting adulteration or watering and to assess the geographical origin of wines is improved only when they are used concurrently. The authors state that further research is needed.

Study details	Prodoliet, 1994[84]
Country of publication	Switzerland
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	Because adulteration (of coffee) with coffee husks or parchments seems to be relatively widespread, the first aim was to propose a limit for total xylose, the best tracer, above which a soluble coffee should be considered as adulterated. The fate of xylose during the roasting and extraction steps was assessed.
Description of study and methods	All total xylose results on green coffee, roasted coffee and commercial soluble coffee obtained in 3 laboratories with anion-exchange chromatography with pulsed amperometric detection (AE-PAD) were gathered and discussed.
Results (if applicable)	The analysis of total xylose in a wide selection of green beans and the assessment of its fate during processing allowed the derivation of a maximum total xylose limit of 0.40%, above which a soluble coffee should be considered as adulterated. Out of the 700 commercial soluble coffees analysed, 81 exhibited a total xylose level above this limit. Of the samples with total xylose level lower than the limit, 99% displayed concentrations in free mannitol and total glucose below 0.30 and 2.10% respectively.
Implications	Fraudulent addition of coffee husks or parchments in soluble coffee can easily be detected by AE-PAD analysis of total xylose, free mannitol and, to a certain extent, total glucose. About 12% of the 700 samples analysed in this study were beyond the limits.

Study details	Prodolliet, 1995[85]
Country of publication	Switzerland
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To evaluate the applicability of anion-exchange (AE) chromatography with pulsed amperometric detection (PAD) for the separation and quantitation of the major carbohydrates found in soluble coffee.
Description of study and methods	A wide range of commercial products were analysed and the results were compared with those obtained by previously published liquid chromatographic (LC) and enzymatic procedures.
Results (if applicable)	The technique allowed the detection of fraudulent addition of coffee husks or parchments as well as cereals or caramelised sugar for the 63 commercial products analysed. High levels of free mannitol, free fructose, free glucose, sucrose, total glucose and total xylose are a good indication of adulteration. Data were compared with those obtained from separate enzymatic determinations and from a different LC procedure. A close agreement among the methods was observed. However, the original method was superior in precision and was the only procedure that enabled the quantitation of all major carbohydrates.
Implications	The technique is a very powerful tool for routine analysis and for purity assessment of soluble coffee. Not very relevant to the NHS.

Study details	Rodriguez-Saona, 2000[86]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To develop methodology for the rapid detection of castor bean meal, containing the highly cytotoxic protein ricin, in flour-containing products by using FT-NIR spectroscopy and multivariate methods.
Description of study and methods	Measurements were made on an FT-NIR system using a diffuse reflection-integrating sphere. Flours spiked with caffeine, crystalline sugar and corn meal 1-20% w/w were used as test articles. Food matrices (bleached flour, wheat flour and blueberry pancake mix) spiked with CBM (0.5-8% w/w) were analysed.
Results (if applicable)	Multiplicative scatter correction transformed partial least-squares regression models, using a specific NIR spectral region, predicted CBM contamination in foods with a standard error of cross-validation of <0.6% and a coefficient of determination of >94%. Models discriminated between flour samples contaminated with CBM and other protein sources (egg white, soybean meal, tofu and infant formula). CBM had loading spectra with bands characteristic of amide groups and lipids.
Implications	Could be used for detection of ricin contamination.

Study details	Saavedra, 2000[87]
Country of publication	Spain
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To develop, optimise and validate a method for determining isocitric, citric, tartaric and malic acids in natural or commercial orange juices by capillary electrophoresis with direct UV detection and no sample treatment other than dilution and filtration.
Description of study and methods	Samples used in the development and validation of the method were obtained from one of the many marks available in the market and diluted 1:1 with Milli-Q water before filtration for the analysis.
Results (if applicable)	Values for the content in the three acids in the natural juice are fully in agreement with those found in the literature for Spanish or Mediterranean Basin oranges. Moreover, one of the commercial samples, announced as coming directly from oranges without any concentration or dilution, gives the same values. Some of the juices have different quantities of grape juice added as can be seen by the tartaric acid, when it is not mentioned in the label, and the remaining samples are more diluted than natural juice.
Implications	The developed method is rapid, simple and reliable for assessing a certain kind of fraud in orange juices, using isocitrate, citrate, malate and tartrate as markers.

Study details	Sheppard, 1985[88]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To demonstrate the application of various analytical methods to the detection, identification and quantitation of vegetable oil adulteration of ice cream.
Description of study and methods	Total fat content, sterols, long and short chain fatty acids, vitamin E, Reichert-Meisel values and Polenske values were measured in ice cream.
Results (if applicable)	All methods except total fat determination were capable of detecting vegetable oil adulteration. Sterol determination was the most effective and versatile measurement because it provided information not only on the detection and extent of adulteration but also on the possible identity of the adulterant.
Implications	No health or safety issues involved, is more about misbranding and adulteration.

Study details	Wolnik, 1989[89]
Country of publication	USA
Topic category	FOD
Focus of research	Detection
Type of study or article	Laboratory tests
Aims/ Objectives	To develop a fast, inexpensive method for characterising both the glass of the jars and the glass fragments found in baby food
Description of study and methods	In 1986, the US Food and Drug Administration was faced with an epidemic of suspected product tampering complaints concerning glass found in jars of baby food. After dissolution in HF and HNO3, the elemental composition of milligram to sub-milligram sized glass fragments was determined by inductively coupled plasma atomic emission spectrometry. Use of an HF-resistant nebuliser and torch allowed direct introduction of the sample solution. More than 400 fragments of glass from over 150 separate incidents were analysed.
Results (if applicable)	Comparison of the trace element content often allowed the discrimination of glass fragments when measurement of the refractive index proved inconclusive. In the vast majority of instances, the elemental composition of the adulterant fragment was significantly different from the composition of the control jar. Compilation of a preliminary database for the elemental composition of baby-food containers manufactured in the USA resulted from the investigation of numerous individual complaints.
Implications	In rare cases where glass entered the product accidentally during production, because baby-food manufacturers attempt to use only one lot of containers for each product code, the adulterant glass should be indistinguishable from the container. This method allows high sample throughput and minimal pre-treatment and is reliable. Once databases have been established for other types of glass, classification is possible.

TOPIC: SELF HARM

Study details	Williams, 1985[91]
Country of publication	Unclear
Topic category	SEL
Focus of research	Prevalence (extent of problem) study
Type of study or article	Case series
Aims/ Objectives	To test the hypothesis that long-term continuous intravenous insulin infusion (CIVII) delivered by a portable infusion pump will improve glycaemic control in brittle diabetes, using five chronically unstable women with brittle diabetes who had failed to respond to continuous subcutaneous insulin infusion (CSII).
Description of study and methods	Five young women (aged 16-29 years) were treated with CIVII, all referred from other centres because of chronically poor metabolic control that severely disrupted their lifestyles. Insulin was infused through an indwelling central venous catheter by a portable pump for 3-16 months. In a short-term control study, three stable insulin-dependent women also received CIVII for 2-3 days. In all 8 patients, fasting C-peptide concentrations measured by radioimmunoassay were undetectable. Glycaemic control was assessed in the hospital and infusion regimens were altered accordingly by the medical staff. Each patient's knowledge of diabetes was assessed and reinforced as necessary with practical instruction. Patients were encouraged to be normally active but random checks were made for compliance by inspection of the pump, insulin reservoir and infusion cannula. After discharge, regular contact was maintained through a constant on-call service and frequent outpatient attendances. Infusion regimens were altered as necessary on the basis of self-monitored blood glucose values and additional capillary blood samples.
Results (if applicable)	During CIVII, only 3 participants obtained satisfactory glycaemic control and only for short periods. Generally, as with CSII, control was erratic and unpredictable and three participants intermittently had high insulin requirements (200 U/day). By contrast, three stable insulin-dependent patients achieved near-normoglycaemia within 1-3 days of starting CIVII with daily insulin dosages of 30-90 U. The lives of all five brittle patients continued to be disrupted by frequent hospital admissions during CIVII treatment. Deliberate interference with their own treatment (including tampering with pumps and central venous catheters) was thought to be a major contribution to instability in two of the brittle patients. In the other the ineffectiveness of CIVII suggests that brittleness was not due solely to defective subcutaneous insulin absorption, as had previously been suggested.
Implications	Although CIVII has reportedly been successful in managing brittle diabetes, the technique may not be useful in all brittle individuals, as illustrated by the poor glycaemic responses of these patients and the serious complications (including local infection, septicaemia and thrombosis) they suffered. Physicians may be reluctant to accept that failure to respond to treatment may be due to deliberate disruption of treatment by the patient, especially with illnesses such as brittle diabetes which carry an important threat to the quality of life and to life itself. However, a recent survey of 30 apparently brittle and/or insulin-resistant individuals concluded that 50% of this group were deliberately manipulating their diabetes. Management remains difficult if manipulation is detected, as exemplified by the departure from care of one patient after a sympathetic discussion about the importance of compliance with CIVII. Although the authors believe that the demonstration, suspicion and/or admission of episodes of deliberate interference with treatment in some participants are important clues to the aetiology of this condition, they are not proof of sole causality.

TOPIC: EDUCATION

Study details	Arnold, 2002[92]
Country of publication	USA
Topic category	EDU
Focus of research	Prevalence (extent of problem)
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To interpret the state of the art of assessing professional behaviour (largely from a medical education perspective)
Description of study and methods	The author reviewed professionalism literature from the last 30 years that had been identified through database searches, included in conference proceedings, bibliographies and reference lists and suggested by experts. The cited literature largely came from peer-reviewed journals, represented themes or novel approaches, reported qualitative or quantitative data about measurement instruments or described pragmatic or theoretical approaches to assessing professionalism. The author defines the concept of professionalism, reviews the psychometric properties of key approaches to assessing professionalism, conveys major findings that these approaches produced and discusses recommendations to improve the assessment of professionalism.
Results (if applicable)	The well-circumscribed concept of professionalism can serve as a foundation for future mesaurement initiatives, but it does require clarification. Assessment of professionalism should focus on professionalism, in and of itself. Instruments that measure the separate elements of professionalism should be developed. Rigorous qualitative approaches to assessment should be encouraged, along with more quantitative measures of the elements of professional behaviour that might be derived from the use of standardised patients in OSCE settings, for example. The hypothesis should be explored that to improve assessment of professionalism, our tools should emphasise behaviours as expressions of value conflicts, explore the resolution of these conflicts and take into account the contextual nature of professional behaviours. Of most immediate concern is whether measurement tools should be tailored to the stage of a medical career. How the environment can support or sabotage the assessment of professional behaviour is also a central issue.
Implications	Without solid assessment tools, questions about the efficacy of approaches to educating learners about professional behaviour will not be effectively answered.

TOPIC: EMERGENCY SERVICES

Study details	Comber, 1983[93]
Country of publication	UK
Topic category	EMG
Focus of research	Detection
Type of study or article	Experiment: Voice analysis
Aims/ Objectives	To determine whether malicious and non-malicious fire alarm calls could be distinguished on the basis of their psycholinguistic attributes.
Description of study and methods	Eight malicious and eight non-malicious calls were compared in terms of the number of speech errors of various kinds in the call. The calls were analysed using multi-dimensional scalogram analysis (MSA-I). The 16 tapes of alarm calls were made available by a Metropolitan Fire Brigade. Malicious and non-malicious callers were matched on age (adult or child) and sex. The transcript of each call was scored on six variables: 1) number of questions asked by the caller; 2) number of times the operator and caller spoke simultaneously; 3) number of filled pauses (um, ah, etc.) in the operator's speech; 4) number of filled pauses in the caller's speech; 5) number of false starts in the operator's speech; and 6) number of false starts in the caller's speech. Each call's raw scores, expressed as a ratio of the number of words in the call, were dichotomised according to whether they were above or below the mean for the sample as a whole (scored 2 or 1, respectively).
Results (if applicable)	The resulting configuration shows that the malicious and non-malicious calls occupy discernible regions in the MSA space. This implies that the two samples of calls can be distinguished by all seven variables in combination.
Implications	The result of the MSA-I analysis shows that malicious and non-malicious calls can be differentiated on the basis of the overall configuration of speech behaviour within the call. The scoring methods used in this pilot study need to be greatly refined. Nevertheless, the study demonstrates the viability of the analytical approach in that, using even crude measures, malicious calls could be distinguished on the basis of the profile of behaviours presented by such calls. Given the high cost to the public of fire services which deal with malicious calls, further research to clarify these differences would be well worthwhile. Although all calls to the brigades must be attended, a method of differentiating hoax calls could help in apprehending and possibly discouraging malicious callers.

TOPIC: NUCLEAR SITES

Study details	Andrews, 1986[94]
Country of publication	USA
Topic category	NUC
Focus of research	Risk assessment
Type of study or article	Theoretical model
Aims/ Objectives	To evaluate alternatives to the design and operation of nuclear power plants, emphasising a reduction of their vulnerability to sabotage. The scope was to use estimates of core melt accident frequency during normal operations and from sabotage/ tampering events to rank the alternatives.
Description of study and methods	The NRC identified a total of 25 sabotage and tampering avoidance technology (STAT) alternatives to be ranked in this study. These alternatives cover a wide range of potential plant design and operational changes. Some represent alternatives for future plant designs; others are possible design changes for all plants to reduce the threat from persons with access to plant equipment (insiders). The remainder were examples of STAT alternatives to mitigate the effects of sabotage. Core melt frequency for normal operations was estimated using sensitivity analysis of results of probabilistic risk assessments. Core melt frequency for sabotage/ tampering was estimated by developing a model based on probabilistic risk analyses, historic data, engineering judgment and safeguards analyses of plant locations where core melt events could be initiated.
Results (if applicable)	Results indicate that the most effective alternatives focus on wide areas of the plant, increase safety system redundancy and reduce reliance on single locations for mitigation of transients. Less effective options focus on specific areas of the plant, reduce reliance on some plant areas for safe shutdown, or focus on less vulnerable targets.
Implications	Intrusion is a minor contributor to plant threat. Damage done by intruders has also been minor. Vandalism is a major contributor to plant threat. The majority of the more serious of these acts stem from employee malcontent, from mental illness and from political idealism. The sabotage value is based on transients initiated to embarrass plant management. Sabotage-with-tampering frequencies are based on one act at a test reactor. Data for this category are very limited and may overestimate the threat for power reactors. Data indicate that most acts of damage in power plants are committed by insiders. Intruders from offsite and unauthorised access to restricted areas by onsite staff are a small part of the acts to date. Insider acts to date cover a wide range of damage. Most acts have had no offsite consequences and there is no evidence of obvious intent to cause them. However, the acts with intent to cause plant damage have been committed by those knowledgeable of the safety systems and with access to sensitive equipment. There are several methods of dealing with this threat. The first is to reduce vulnerabilities through increased operating flexibility and surveillance. The second is the subject of other NRC actions addressing staff qualifications and access to sensitive areas. Not sure of relevance to NHS. Paper is nearly 20 years old.

Study details	Anonymous, 1988[95]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Consensus guidelines
Aims/ Objectives	To perform a structured evaluation of existing and proposed vital equipment/ area assumptions, criteria and guidance and to develop a comprehensive and consistent set of recommended assumptions for determining equipment and areas to be designated as vital in nuclear power plants.
Description of study and methods	The scope of the study included the following: 1. A review of all current regulations, guidance, definitions, assumptions and criteria related to determining vital equipment and areas. 2. A determination of the present status of application of the items in (1) to various vintages of plants to establish what staff practice has been and is with respect to approving designated vital equipment and areas. 3. Identification of any deficiencies, ambiguities, inconsistencies or other problems in the present regulatory approach. 4. A review and evaluation of recent and current staff proposals, proposed rules etc, as they relate to vital equipment and areas. This study addresses light water reactors only.
Results (if applicable)	On the basis of the study, the VAXC has recommended a revised vital equipment/ area protection philosophy: to protect as vital the reactor coolant pressure boundary and one train of equipment - with its associated piping, water sources, power supplies and instrumentation - that provide the capability to achieve and maintain hot shutdown. To implement this overall protection philosophy, the VAC has also recommended revised analysis assumptions or guidelines, to be applied on a case by case basis, to identify the specific equipment and areas in each plant that require protection as 'vital'.
Implications	Unclear: possibly the need to identify the specific equipment and areas in each plant that require protection as 'vital'.

Study details	Anonymous, 1995[96]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Database analysis
Aims/ Objectives	To check the BFS computerised accounting system capability of performing its major functions as well as to evaluate the accuracy of the database records on nuclear material items characteristics.
Description of study and methods	The test programme was done in 3 stages: 1. The accuracy of the database records on passport characteristics of nuclear material items was evaluated. 2. The major operational functions of the system were checked. 3. The performance of the computerised accounting system was tested on the basis of statistical sampling procedure during the physical inventory taking. The test and evaluation procedures were planned taking into account policy dependent parameters.
Results (if applicable)	In general it could be concluded that this first step in the implementation of computerised nuclear material accounting methods on the BFS facility could be considered as successful.
Implications	None stated.

Study details	Bennett, 1976[97]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical model
Aims/ Objectives	The overall methodology and the primary analytic techniques used to assess physical protection system effectiveness (at nuclear facilities) are briefly outlined.
Description of study and methods	To provide a systematic approach to the problem of physical security, a methodology has been developed which considers the interrelations of elements within the overall system and provides a framework for the system integration of each element. The methodology combines several analytic techniques to assess the relative vulnerability of fixed facilities to sabotage or theft. The basic input information required includes: fault tree study, plant physical layout, security system description, and adversary attributes. From this initial information a model of the facility is developed which reflects the physical characteristics of the site and the likely targets for sabotage or theft.
Results (if applicable)	The Insider Safeguard Effectiveness Model (ISEM) is based on the following assumptions: 1. A critical insider path is identified at input 2. One insider carries the material 3. All insiders potentially degrade alarm system 4. Guard responses are preplanned for each alarm 5. Employees and guards are treated as groups having composite attributes 6. Insiders are identified on an individual basis. Further extensions of ISEM will involve development of an insider sequence generator, inclusion of individual personnel attributes, and continuing development of the engagement model.
Implications	The primary contribution of ISEM is that it provides a consistent framework within which safeguard system effectiveness measures can be generated for the personnel control aspect of the insiders problem. The applicability of the overall methodology has been demonstrated in the analysis of a typical LWR plant.

Study details	Bennett, 1975[98]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Theoretical model
Aims/ Objectives	To report on a dynamic simulation of security force-adversary engagements developed during the US Nuclear Regulatory Commission's Special Safeguards Study.
Description of study and methods	Factors affecting engagement outcomes were identified and interrelated to represent an ambush of an escorted nuclear fuel truck convoy by an adversary group. Other forms of engagement such as assault and skirmish also can be simulated through suitable parameter changes. The model is described as a relatively simple deterministic engagement model.
Results (if applicable)	Although limited by a paucity of data to relative evaluations of security system changes, the model has provided valuable insight into system interactions. The results from the model so far indicate the importance of engagement termination methods (breakpoint functions) and their impact on security performance dynamics. A method of termination based only on the ratio of surviving opposing forces is questionable. Utilising this method causes both unrealistic peaks in engagement duration and results corresponding to very high casualty fractions (casualties/ initial force). On the other hand, determining breakpoints on the basis of casualty fractions appears acceptable in that no peculiar results were observed, support can be derived from large scale battle statistics, it has been utilised in military combat simulations and it could reflect the maximum price a resource limited adversary may be willing to pay for a given objective.
Implications	The experience gained from this model is being applied to a stochastic version of the model which is currently under development. This paper is nearly 30 years old!

Study details	Berry, 1979[99]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To present a technically defendable and conservative fire hazards analysis technique which combines a knowledge of fire phenomena with an understanding of the safety importance of each power plant location.
Description of study and methods	A fire protection analysis technique was developed from earlier work involving the protection of nuclear power plants against acts of sabotage. Characteristics unique to fire phenomena were used to modify the sabotage analysis methodology. These characteristics include the effects of fuel loads, ventilation rates, heat loss areas, barrier ratings and plant locations. The new fire analysis technique was applied to an example nuclear power plant having 85 different plant areas.
Results (if applicable)	It was found that some safety and nonsafety areas were both highly vulnerable to fire spread and important to overall safety, while other areas were found to be of marginal importance to fire safety.
Implications	The information obtained in this analysis makes it possible to protect a subset of safety-related plant areas and still assure that all fire paths that could threaten safety have been eliminated. It might be possible to break all fire oaths of concern by protecting a smaller set of areas which includes non-safety areas through which fire must spread in order to reach the critical combinations of safety areas. Work is continuing on a refinement of the analysis method that will eliminate all fire spread paths important to safety by protecting a minimum set of safety and non-safety areas.

Study details	Boozer, 1976[100]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model and methodology used in nuclear safeguards effectiveness evaluation
Aims/ Objectives	To provide a systematic approach to the problem of physical security (of nuclear materials and nuclear facilities).
Description of study and methods	The methodology considers the interrelations of elements within the overall system and provides a framework for the system integration of each element. To implement the methodology, several analytic tools have been developed to identify key plant protected areas and to evaluate various alternatives to the security system. The methodology combines several analytic techniques to provide a means of assessing the relative vulnerability of fixed facilities to sabotage or theft. The fundamental analytical tools used in the analyses are fault tree analysis, graph-theoretic modelling and system simulation modelling. The application of each of these techniques to the effectiveness evaluation is discussed.
Results (if applicable)	The applicability of the overall methodology has been demonstrated in the analysis of a typical LWR plant. The results of that analysis are being used to guide the conceptual development of a balanced LWR safeguards system.
Implications	Not immediately relevant to NHS facilities.

Study details	Boozer, 1977[101]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To describe the Insider Safeguards Effectiveness Model (ISEM), a simulation model which treats certain aspects of the insider problem (theft or sabotage of radioactive material by people employed in nuclear facilities), and to demonstrate its use in modelling the personnel control system of a hypothetical facility..
Description of study and methods	A general description of ISEM, a discussion of ISEM's role in the analysis and design of safeguards systems, a discussion of the use of ISEM in conjunction with other methods used in safeguards system design and a comprehensive example to show typical ISEM effectiveness results and sensitivities to variations in several safeguards system parameters.
Results (if applicable)	ISEM's primary contribution to the evaluation of personnel control systems, as well as more general safeguards systems, is its ability to simulate the response of the safeguards system to alarms generated by sources such as sensors, personnel or procedures. ISEM also addresses the tampering of sensor system elements by insiders. By studying the characteristics of the safeguards system response (usually guards) to a range of insider scenarios, effective operational procedures can be developed. These considerations are essential, for example, in coping with insider diversionary attacks.
Implications	Not immediately relevant to NHS facilities.

Study details	Boudreau, 1982[102]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical computer model
Aims/ Objectives	To describe the work done by the Los Alamos National Laboratory for the Vital Area Analysis (VAA) Program.
Description of study and methods	Vital Area Analysis focusses on the fault tree approach to systematically identify the sabotage scenarios and equipment locations in the plant. The VAA uses the SETS computer code to solve the massive fault trees to provide the results in usable form. The VAA program involves an FSAR review, a site visit, data reduction, formation of a fault tree, and a computer solution.
Results (if applicable)	The survey part of this process is underway.
Implications	The authors state that this program will result in the original analysis assumptions either being confirmed or modified. Once the required refinements are incorporated into the VAA and reactor sabotage vulnerability assessment procedures, it is expected that the NRC will be able to use the results with greater confidence that all the vital areas and equipment have been identified. In addition, some of the unnecessary conservativeness of the analyses may be removed and this reduces the possibility of safeguards requirements adversely affecting the safe operation of the plants.

Study details	Boughton, 1986[165]
Country of publication	USA
Topic category	NUC
Focus of research	Emergency planning
Type of study or article	Theoretical model
Aims/ Objectives	To predict magnitude and direction of dispersal of radioactive material from a nuclear facility by sabotage incidents using explosive. For evacuation and sheltering decisions and to estimate the potential size of the clean-up operation.
Description of study and methods	A calculational method which realistically describes cloud trajectory rise behaviour has been developed. The procedure predicts the cloud height as a function of downwind distance and existing meteorological conditions. The model also provides estimates of downwind ground deposition and dose to exposed personnel.
Results (if applicable)	Not applicable.
Implications	For exposures greater than 25 rem, respirator protection or evacuation may be required. Sheltering might be considered for levels between 5 rem and 25 rem. Mitigation reduces the critical risk areas by about a factor of 25, which in an urban environment can significantly reduce evacuation requirements. It is estimated that in some cases this may cut cleanup costs from $100s of millions to $10s of millions. Possibly more relevant to terrorism than sabotage.

Study details	Buonpane 1992[162]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Equipment or process evaluation
Aims/ Objectives	To evaluate safeguards effectiveness against the violent intruder.
Description of study and methods	To investigate the threat of a violent intruder using the results of a vulnerability assessment for nonviolent insiders to evaluate violent insider scenarios. Since existing tools do not explicitly consider violent insiders, the approach is intended for experienced safeguards analysts and relies on the analyst to brainstorm possible violent actions, to assign detection probabilities, and to ensure consistency. The approach is general and can be used wth many existing tools for evaluating nonviolent insiders. The authors also customise the approach for use with the nonviolent Insider module of ASSESS.
Results (if applicable)	The authors presented a computational approach for evaluating the effectiveness of safeguards against a violent insider. This approach builds upon results of a nonviolent insider analysis, but the extension from the non-violent to the violent case requires the consideration of interruption and neutralisation in estimating the probability of adversary success. The approach is intended for use by experienced analysts, and the approach relies on the analyst to brainstorm violent strategies and assign probabilities of adversary success. Care must be taken to ensure results are sensible, comprehensive and consistent. This approach is general in nature and can be used in conjunction with many existing evaluation tools for the nonviolent insider. It is also shown how the approach can be tailored for use with the nonviolent insider module of ASSESS.
Implications	Unclear if any implications for the NHS.

Study details	Camp, 1990[103]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	The objectives of the PRA are to assess the risks to the public and the Hanford site workers posed by the operation of N reactor (a Department of Energy production reactor), to compare those risks to proposed DOE safety goals and to identify changes to the plant that could reduce the risk.
Description of study and methods	The scope of the PRA is comprehensive, excluding only sabotage and operator errors of commission. State of the art methodology is employed based largely on the methods developed by Sandia for the US Nuclear Regulatory Commission in support of the NUREG-1150 study of five commercial nuclear power plants. The structure of the probabilistic models allowed complex interactions and dependencies between systems to be explicitly considered. Latin Hypercube sampling techniques were used to develop uncertainty distributions for the risks associated with postulated core damage events initiated by fire, seismic, and internal events as well as the overall combined risk.
Results (if applicable)	The combined risk results show that N reactor meets the primary DOE safety goals and compares favourably to the plants considered in the NUREG-1150 analysis.
Implications	None stated. Excludes sabotage.

Study details	Caskey, 1986[104]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	To present some of the lessons learned in designing and implementing state-of-the-art high security physical protection systems for a number of government facilities.
Description of study and methods	A historical description of situations and problems that faced the technical security community in the early days of the Nuclear Safeguards programme, followed by a description of what Sandia did to address the problems found, followed by specific examples of lessons learned (both from R&D efforts and from field implementation tasks). Finally an illiustration of how these lessons are applied to system design, by describing a conceptual physical security system for a generic high security facility.
Results (if applicable)	Discusses activated barriers (cold smoke, aqueous foam and sticky foam), reliable intrusion sensors, assessment (most reliable being fixed focus CCTV camera with instant replay recording capability), alarm display console systems, and complete systems.
Implications	May be some relevance to NHS security systems.

Study details	Chapman, 1978[105]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To describe the Safeguards Automated Facility Evaluation (SAFE) methodology: a reliable, time efficient and easily applied method of evaluating the effectiveness of a (nuclear) safeguards system.
Description of study and methods	The SAFE automated process consists of a collection of functional modules for facility characterisation, the selection of critical paths and the evaluation of safeguards effectiveness along these paths. SAFE combines these modules into a continuous stream of operations. Using the technique, a comprehensive evaluation of a safeguards system can be provided by systematically varying the parameters that characterise the physical protection components of a facility to reflect the perceived adversary attributes and strategy, environmental conditions and site operational conditions.
Results (if applicable)	SAFE procedure is an efficient method of evaluating the physical protection system of a nuclear facility. Since the algorithms used in SAFE for path generation and evaluation are analytical, many paths can be evaluated with a modest investment in computer time. SAFE is easy to use because the information required is well-defined and the interactive nature of this procedure lends itself to straightforward operation. The modular approach that has been taken allows other functionally equivalent modules to be substituted as they become available.
Implications	The SAFE procedure has broad applications in the nuclear facility safeguards field as well as in the security field in general. Any fixed facility containing valuable materials or components to be protected from theft or sabotage could be analysed using this same automated evaluation technique.

Study details	Chapman, 1975[106]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Theoretical computer model
Aims/ Objectives	To evaluate a fixed-site safeguard security system using a computer model.
Description of study and methods	A computer model (using the GSP IV simulation language) was used to evaluate a fixed-site safeguard security system. The model provides a framework for performing inexpensive experiments for testing alternative decisions, and for determining the relative cost effectiveness associated with these decision policies. The model inputs information on barriers, and the size and response time of the off-site response forces, along with the dedication and sophistication of the guard forces.
Results (if applicable)	A number of adversary attacks were generated and responses evaluated. Several collected computer statistics from 300 attacks have been gathered. These required approximately one second of CPU processing time and therefore illustrate a very efficient method of performing experiments prior to or after a site design has been completed.
Implications	The computer model provides an excellent tool for measuring the cost effectiveness of fixed-site security systems. Although the model is operational, work is being continued for the improvement of input data for alarm detection systems, barrier delays etc. The validity of the model should improve as better data are found and different site configurations are studied.

Study details	Chapman, 1979[107]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical computer model
Aims/ Objectives	To present the Safeguards Automated Facility Evaluation (SAFE) process for evaluating physical protection systems at nuclear facilities.
Description of study and methods	The SAFE process has five phases: 1) facility characterisation; 2) facility representation; 3) component performance; 4) adversary path analysis; and 5) effectiveness evaluation, and can be applied to either of two adversary goals (theft or sabotage). In the evaluation reported in this paper, this process was applied to a nuclear facility.
Results (if applicable)	A primary output is the target identification. Computer codes are generated to perform this analysis. A digitised representation of the facility is obtained as an output. The final output represents a specific facility in terms of specific environmental and operational conditions. The process can be accomplished in a few days to a few weeks. The process is currently being used by the NRC to identify Type I and Type II vital areas for all the operating reactors in the United States. The current average is 2 to 4 weeks for each evaluation.
Implications	SAFE provides a basis for development and communication of policies and regulatory decisions relative to the physical protection system performance. From the licensee's perspective, the techniques could be used as a design aid to the licensee and for upgrading to meet certain regulations. SAFE has been applied to several facilities and should prove to be a very useful technique for analysing physical protection systems.

Study details	Chapman, 1980[108]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To present a brief description of the variety of safeguards evaluation models developed in the areas of global safeguards effectiveness or vulnerability analysis for individual scenarios.
Description of study and methods	Current generation models are described along with an assessment of their utility and a brief look at future techniques for evaluation. Early scenario based models which are considered are the Forcible Entry Safeguards Effectiveness Model (FESEM) and the Insider Safeguards Effectiveness Model (ISEM) which use Monte Carlo techniques to simulate a group of adversaries attacking a nuclear facility. Improved scenario models were the Fixed-Site Neutralisation Model (FSNM) and the Safeguards Network Anakysis Procedure (SNAP); both models use Monte Carlo techniques to simulate randomness in the scenario. Logic models were developed around fault tree analysis and include the Generic Sabotage Fault Tree (GSFT) - designed to identify the sabotage events which in proper combination can lead to the release of radioactive material - and the Adversary Sequence Diagram (ASD) - developed to address generic ways the adversary could accomplish sabotage. Current generation models (circa 1980) include the Safeguards Automated Facility Evaluation (SAFE) - a collection of functional modules for facility representation, component selection, adversary path analysis and effectiveness evaluation, the Estimate of Adversary Sequence Interruption (EASI) model - an analytical technique used in the effectiveness evaluation module to compute the probability that the adversary will be interrupted, the Brief Adversary Threat Loss Estimator (BATLE) - an analytical technique used to estimate the probability that the adversary is neutralised by the security force. A combined SAFE/SNAP approach is proposed. Another model called the Safeguards Upgrade Rule Evaluation (SURE) is based upon probability and utility theory concepts.
Results (if applicable)	Not applicable.
Implications	For an outsider adversary with the intent of creating sabotage at a nuclear power plant, methods (SAFE and SNAP) exist to provide the analyst with sufficient capabilities to address the important safeguards problems. Limitations exist on input data in the detection area and human performance area relative to security officers. The human responses dealing with neutralisation will always be an area with insufficient data. Due to the complexity of physical protection problems, information gained by exercising the evaluation models should be utilised in a supplementary way for aiding the safeguards analyst in his decision making process. Methods for addressing the insider reactor problem in a comprehensive sense are currently under development and should become available in 1981-2. The paper is more than 20 years old.

Study details	Claiborne, 1987[109]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Cost analysis
Aims/ Objectives	To undertake a cost analysis of the imposition of alternate (RG-17) safeguards approaches upon the nuclear power industry.
Description of study and methods	The approach was to categorise the nuclear industry into groups, select a representative plant from each group and determine the backfits needed to conform to the RG-17 criteria and the VAC recommendations. A cost analysis was then performed on the backfits and the results were extrapolated to cover the entire industry. For many vital components, more than one option was evaluated. These included options that would provide marginally acceptable protection and those that would rigidly conform to RG-17 criteria. Among those factors evaluated were radiation exposure and the cost of make-up energy. Since all of the modifications are accomplished outside of containment and away from any contaminated subsystems, there was judged to be no radiation exposure impact. However, health physics and administrative cost associated with work in radiologically controlled areas can be significant and are included in the cost analysis. In addition, none of the modifications would require an interruption in power generation; therefore, there would be no requirement for make-up energy.
Results (if applicable)	The analysis showed that cost to industry for implementing the VAC recommendations for 118 Nuclear Power reactors ranged from a cost of $17,791,200 for the low cost options to a cost of $72,137,500 for the high cost options. The low cost options include $8,531,000 initial costs and $9,260,100 in operating costs over a 25 to 35 year period. The high cost options include initial costs of $29,420,800 and operating costs of $42,716,700. The cost to the NRC ranges from $82,500 to $88,500. Imposing RG-17 would cost the industry $58,717,000 for the low cost options and $91,932,600 for the high cost options. The low cost options include $17,076,900 initial costs and $41,640,200 operating costs. The high cost options include $31,763,300 initial costs and $60,169,300 in operating costs over a 25 to 35 year period. The cost to the NRC would be about $75,500. Several reactors which currently meet RG-17 criteria were evaluated to determine whether relaxing vital area controls to the level of VAC recommendations would result in a long-term cost savings from devitalising areas. The contractor found that there would be a cost savings in those cases where the controls could be relaxed.
Implications	VAC recommendations can be implemented with less cost impact than the RG-17 criteria.

Study details	Davis, 1984[110]
Country of publication	UK
Topic category	NUC
Focus of research	Intervention
Type of study or article	Equipment evaluation: feasibility trial
Aims/ Objectives	To demonstrate that a laser reader can be used reliably inside a plutonium active glove box in conjunction with an automatic read-out balance interfaced to a microcomputer.
Description of study and methods	The laser bar code reader, interfaced to an automatic read out balance and microcomputer was used to identify and record cans of mixed UPu oxide within the facility. 39 medium density labels were printed.
Results (if applicable)	The trial demonstrated the suitability of the laser bar code reader for use in a plutonium active glove box and the technique lends itself to more widespread application. Although the instrument operates perfectly in a nitrogen atmosphere, the use of an argon atmosphere incurs breakdown in the high voltage supply unit. The speed and accuracy in use will reduce stocktake times and avoid errors resulting from manual data transcription. The equipment has proved to be robust and reliable. In-box maintenance has been shown to be feasible.
Implications	In order to incorporate a bar code labelling technique into a fissile material control system which satisfies safeguards criteria, it is desirable that the labels be tamper-proof. This criterion can be satisfied by the adoption of special paper and bank-note printing techniques together with adhesives which prevent the removal of the label without damage to the label itself. The combination of lightly patterned backgrounds and black bar codes does not inhibit reading by laser gun.

Study details	Dean, 1982[111]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	Describes the development of the ROBIN (ROBot INspector) for facilities, both nuclear and non-nuclear, where it is desirable to minimise or eliminate inspector access to critical areas.
Description of study and methods	The ROBIN provides a potential tool that allows the inspector to collect data inside a facility without actually entering that facility, verifies that data were collected at the proper location, verifies the authenticity and integrity of the data, limits safety risks and radiation exposure of personnel, limits the potential disclosure of sensitive technology, reduces inspector manhours by automating the data collection, analysis and retention processes, and permits immediate follow-up potential since preliminary data analysis is conducted in realtime. The ROBIN is a candidate for international safeguards support at a US uranium enrichment plant. The ROBIN consists of radiation, location, video and data collection modules, in a tamper resistant enclosure. The ROBIN radiation module detects and analyses the gamma ray emissions from Uranium-238 and Uranium-235. This data is used to verify that the enrichment of the material inside the facility is in compliance with the facility agreement. The tamper protection system insures the integrity of the location data and the radiation data. It consists of multiple tamper sensors and a tamper indicating enclosure. Attempts to penetrate the ROBIN enclosure and obtain internal access are detected.
Results (if applicable)	The results of development activities and prototype tests to date indicate that it is feasible to develop a Robot Inspector that collects safeguards data inside a plant while minimising the inspector intrusiveness.
Implications	None for the NHS.

Study details	Delvin, 1990[112]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	Presents an interim report on an effort to develop a method that would provide a systematic and structured process for making evaluations of the 18 insider protection measures listed in the Site Safeguards and Security Plan Preparation Guide. To provide more uniform evaluations throughout the US Department of Energy community.
Description of study and methods	Provides an outline of the work done initially to devise a concept for the SSSP guidance for evaluating the effectiveness of the insider protection programmes, then a discussion of the approach now being developed to produce an evaluation method. The discussion includes the logic that supports the approach being taken.
Results (if applicable)	No results, just outlines the methods.
Implications	The following may be useful: 3 kinds of factors influence the effectiveness of insider protection programmes to provide protection against insider adversaries: 1. Factors associated with adversary acts against which the programmes provide protection 2. Factors associated with targets protected by the programmes and 3. Factors associated with use of the programmes. The first two groups (adversary acts, targets) are related to the protection functions and the third group (programme utilisation) is related to the implementation and administration of the programmes.

Study details	Engi, 1980[113]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability Assessment
Type of study or article	Theoretical model
Aims/ Objectives	Describes the fundamental aspects of the Pathfinding Simulation (PATHS) procedure and instructs the user in the execution of PATHS on an interactive terminal. Examples of simulations using PATHS are provided and discussed to show what inputs are required, how these inputs are entered in the interactive mode, what inputs may be modified and how, and what output can be obtained and how the output may be interpreted.
Description of study and methods	The PATHS code is a computerised method developed for treating the stochastic shortest path problem. PATHS was developed under contract to the US Nuclear Regulatory Commission as part of the methodology for the evaluation of the effectiveness of nuclear facility safeguards. An important part of this evaluation is the identification and quantitative critical appraisal of critical paths within a facility. These are paths that, if traversed by an intruder intent upon the sabotage or theft of a target (S) are most favourable to the intruder in terms of some measure such as the minimum time for traversal or minimum probability of detection. PATHS uses a Monte Carlo simulation technique to generate these paths and to assess their relative criticality. In addition to descriptions and assessments of these generated paths, the PATHS procedure provides estimates of the lower and upper bounds to the minimum overall security of a facility that are derived from the estimates of path criticality. The program is described in its application to the evaluation and design of facility security systems that are used for protection against sabotage and theft. Input requirements, input modifications, output options, and interpretation of the output are presented and examples are given of simulations that apply to a hypothetical facility.
Results (if applicable)	Not applicable.
Implications	By making use of an efficient algorithm for focussing upon only the relatively critical routes (from a security viewpoint), PATHS obviates the need to identify and evaluate each and every complete potential route. As a result, the PATHS procedure permits facility analyses that would otherwise be beyond the capabilities of current generation computers.

Study details	Engi, 1977[114]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical model
Aims/ Objectives	To provide a structure for analysing the impact of guard tactics on the effectiveness of (nuclear) safeguards systems.
Description of study and methods	The Insider Safeguards Effectiveness Model (ISEM) is used to measure the effectiveness of a safeguards system. ISEM is a Monte-Carlo simulation model which was developed to treat specifically those insider attacks in which the time relationship among events is important. The sensitivity of effectiveness to guard tactics is demonstrated by computing the effectiveness measure for a variety of guard tactics employed against a number of distinct insider paths through the facility. For the paths considered, the insider has either theft or sabotage as his objective and can peform covert as well as overt activities. Each path represents a unique insider strategy. The guard tactics employed range from sending a single guard for assessment to collecting the guards en masse prior to despatching them to confront the insider. The measure of effectiveness chosen for this study was the probability that the safeguards system successfully neutralises an attack by an insider given that the insider is detected somewhere during his attempt.
Results (if applicable)	The sensitivity of safeguards system effectiveness to a variety of guard tactics is explored, but not presented in an easily summarisable form. The evolution of comprehensive guard tactics for protecting a hypothetical facility is demonstrated. Attention is focussed on the potential threat posed by insiders and the necessity of well conceived guard tactics in dealing with this threat.
Implications	Not immediately relevant to NHS.

Study details	Engi, 1982[115]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	The Maintainability Analysis Procedure (MAP) was developed in order to model and analyse systems in which event sequences for which included time-dependent phenomena and conditionally linked or characterised by arbitrary probability distributions are assumed to be significant.
Description of study and methods	MAP is a dynamic Monte Carlo modelling technique that makes use of a maintainability network and a procedure for analysing the network. The network is a graphical representation of a process that consists of sequences of topologically and phenomenally linked events, activities and decisions. For a process corresponding to a given accident or sabotage scenario, multiple simulations of these sequences are carried out by MAP and the response of the specified system or subsystem is determined by the failure statistics that are generated. The application of MAP to a simple safety system is described in terms of the networks for four processes in which phenomena such as demand failure, run failure and component repair are included.
Results (if applicable)	Results of analyses of the four processes confirm the expectation of significantly different cumulative probabilities of system failure where the nature and number of included phenomena as well as the nature and extent of the phenomenal interdependencies are varied.
Implications	There are at least three areas in which the capabilities of MAP could be extended. Treatment of the statistical aspects of MAP could be improved. A software interface for translating safety system fault trees into maintainability networks could be developed. A computer 'language' could be developed that is specifically tailored to the application of MAP to reactor safety/ safeguards system analyses.

Study details	Ericson, 1980[116]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Theoretical evaluation
Aims/ Objectives	To examine nuclear power plant design changes for their impact on sabotage protection.
Description of study and methods	The phase 2 programme was established with four tasks: damage control for sabotage mitigation, insider protection, retrofitable design changes, design changes for BWR plants. A method for system or equipment ranking was developed using simplified fault trees. The ranking methodology illustrates protection strategies and ranks systems by considering time sequenced system requirements. Ranking results provide insights for damage control by indicating where it is not a credible approach and where it has potential use. Strategies and rankings are plant specific and will vary to some extent with the assumptions on adversary capabilities.
Results (if applicable)	Given the compartmentalisation present in current generation plants and the level of physical protection assumed in this study even drastic changes in design don't significantly affect the protection against an external threat. It is clear from these studies that to be effective, damage control must use installed equipment and significant portions of that must be available in a very short time following an incident. Insider protection is a difficult task, requiring the integration of a number of techniques to be effective. Component level vulnerabilities can be reduced by careful design but they cannot be eliminated. The work done here in damage control, systems ranking and component vulnerability may have direct application to safety issues.
Implications	Although the purpose here was to establish the relative importance of protecting individual systems against radiological sabotage, the authors believe the methodology can also be used to define systems which must be protected against accidents or which must be functional to counter the effects of accidents.

Study details	Ericson, 1981[117]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Discussion paper
Aims/ Objectives	To estimate the potential value of various configurations of plant design and damage control measures in providing protection against sabotage at commercial light water reactor (LWR) power plants and to establish the impact of such measures on facility costs, operations and safety. The programme emphasises new designs and future construction; therefore, design changes that might be retrofitted to existing plants or to plants under construction are not addressed.
Description of study and methods	Phase I of the programme was structured to identify a range of measures, document them in a consistent fashion, provide a preliminary evaluation and select the most promising ones for further consideration in Phase II. Phase II was intended to provide a limited number of detailed designs with a more complete evaluation of values and impacts.
Results (if applicable)	Design objectives for risk reduction (not clear if this is background or results): Decrease the number of sequences which could cause release, increase the number of individual actions required to complete a sabotage sequence, reduce the probability of success in sabotage sequences, reduce the consequences of completed sabotage sequences.
Implications	None stated

Study details	Foesch, 1994[118]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	To research commercially available systems that can be used in locating and tracking personnel and materials at DOE facilities.
Description of study and methods	Literature search, analysis of the literature, evaluation of particular systems in the laboratory and integration of selected systems into the Sandia PAM-TRAK system.
Results (if applicable)	The main conclusion is that there is a tag system in the commercial market that will work for some applications but there is no tag system that will work in all applications. Evaluations indicate that the security application will determine which tag technology or technologies will be most suited for a particular application. Tag system capabilities and vendors are increasing at this time. IR tag systems have good zoning ability, read/write capabilities, but communication can be disrupted. RF proximity tag systems are good for portals and localised areas. RF tag systems can be used for material storage areas.
Implications	Could be relevant to hospital security systems.

Study details	Gardner, 1993[119]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Discussion paper
Aims/ Objectives	To provide a standard set of assumptions, information sources and recommended computer codes to help with radiological sabotage analysis.
Description of study and methods	The paper addresses release code comparisons, standardisation issues and recommendations.
Results (if applicable)	The recommendations are: 1. establish a clearly defined set of meteorological conditions that must be used by sites. 2. Select a set of DOE standardised codes for radiological sabotage analysis. 3. Establish a standardised set of release fraction assumptions to be used in conducting explosive dispersal analysis.
Implications	A standardised set of assumptions should be adopted to provide a valuable starting point for conducting this type of analysis. Certain dispersal codes, specifically ERAD and MACCS, should be recommended for use where costly process control limits, insider protection strategies and denial response strategies are implemented to mitigate radiological sabotage scenarios. HOTSPOT should be used as a quick target screening tool. Standardisation of this process could potentially save scarce resources, aid in decision making and reduce risk of theft and diversion. The community should evaluate the impact of cleanup costs when conducting sabotage risk evaluations.

Study details	Grant, 1979[120]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To describe the Sateguards Network Analysis Procedure (SNAP) network modelling technique and provide an example illustrating its use.
Description of study and methods	SNAP provides a convenient and standard analysis methodology for the evaluation of (nuclear) safeguards system effectiveness in its ability to resist theft or sabotage. This is achieved through a standard set of symbols which characterise the various elements of safeguards systems and an analysis program to execute simulation models built using the SNAP symbology.
Results (if applicable)	The Safeguards Network Analysis Procedure (SNAP) provides analysts with a technique for modelling and evaluating various safeguards system design alternatives. The SNAP symbology also provides analysts with a vehicle for communication, thereby enhancing the model building process. The technique has been shown to be easy to use and requires no computer programming. SNAP is receiving extensive use in its application in the analysis of real-world nuclear facilities as well as the generic site discussed in this paper. SNAP is an effective tool for analysing the safeguards effectiveness of a given nuclear site.
Implications	Only useful to the NHS if wanting to restrict entry to hospitals. The paper is 24 years old.

Study details	Grant, 1978[121]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical computer model
Aims/ Objectives	To describe the SNAP modeling technique and provide an example illustrating its use.
Description of study and methods	Safeguards Networks Analysis Procedure (SNAP) is a network modeling approach to problem solving. SNAP symbology is combined with knowledge of the system, specific scenarios, and modeling objectives to develop a network model of the system. SNAP further includes three submodels: for the physical characteristics of the system; for the guard operating policies in the system; and for the adversary process in the system. In this study SNAP is applied to model systems concerned with protecting nuclear material from sabotage or theft.
Results (if applicable)	Several figures showing the models for the system and three subsystems are shown. The model was simulated 500 times to generate statistics that are summarised in a table. The overall performance measure, the probability the adversary achieves his objective, was observed to be 0.13. That is, in this example, the adversary can sabotage nuclear material 13% of the time. This would most likely be viewed as an unacceptable level of performance and indicate that revisions to the facility or guard operating policies are warranted.
Implications	SNAP provides analysts with a tool for evaluating alternate safeguards systems designs and refining safeguards procedures at existing sites.

Study details	Hall, 1978[122]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To describe the structure and use of ENUMPTH, a program for enumerating paths which an adversary might follow in attempting defeat of physical protection systems.
Description of study and methods	The paths are evaluated in terms of the probability of detecting and then interrupting the adversary as the paths are traversed. The program is intended to be practical in orientation, selecting all paths which meet some specified minimum criteria. The nature of the physical protection issue suggests that all such paths may be of equal interest to analysts who are concerned with a total facility. An example is given to demonstrate the program's applicability to practical problems.
Results (if applicable)	None.
Implications	None stated. Employs card files and FORTRAN. Unlikely to be useful now.

Study details	Heyes, 1995[167]
Country of publication	UK
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Critical review/ discussion paper
Aims/ Objectives	To undertake a critical analysis of current techniques of probabilistic risk analysis (PRA) applied in the industry, with particular regard to the problems of quantifying risks arising from, or exacerbated by, human risk and/or human error.
Description of study and methods	Implementation of PRA applied to safety in nuclear plants. PRA is a technique widely applied since the middle of the 1970s to the quantification of low-frequency events, such as the probability of an accident at a nuclear power plant. The authors present a PRA by first constructing an event tree, and then second, attributing probabilities of failure to each safety component.
Results (if applicable)	The authors quote that 'event tree analyses are based on thousands of potentially arbitrary and largely unverified assumptions and PRA cannot be relied on for sound decision making'.
Implications	The authors are doubtful that PRA is a methodologically sound form of analysis for the nuclear industry. The authors state that there is potential for manipulability and non-transparency in PRA studies and this may prove to be their biggest drawbacks.

Study details	Horton, 1985[123]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical model: probabilistic risk assessment
Aims/ Objectives	Presents a method for integrating probabilistic risk assessment (PRA) techniques into the assessment of the effectiveness of safeguards changes aimed at reducing the vulnerability of a nuclear power plant to sabotage. For any safeguards change that is considered, this integrated method will provide a measure of how the change affects the risk due to sabotage, tampering and vandalism and how the change affects risk due to operations.
Description of study and methods	MOSREP is a multiphase method which allows the user to select, on the basis of what type of safeguards evaluation is needed, an appropriate level of analysis. MOSREP has two general phases. In the first phase, the PRA plant model is 'transformed' into a safeguards plant model, containing vital area designations and necessary adversary capabilities, which can be used to identify and rank vital areas. In the second phase, details about the safeguards system are added to the safeguards model (barrier detection probabilities and delay capabilities, guard force response capabilities etc) and manipulated to assess overall safeguards risk posed by a sabotage, tampering or vandalism attempt. MOSREP does not make an absolute assessment of safeguards risk but assumes a sabotage attempt by a particular type of adversary has occurred and calculates a relative measure of the probability of that attempt causing core damage given the security system that is in place.
Results (if applicable)	Not applicable.
Implications	Not stated.

Study details	Horton, 1995[124]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Equipment evaluation: experimental testing
Aims/ Objectives	To report an evaluation of seals used as tamper-indicating devices at Department of Energy (DOE) facilities.
Description of study and methods	Seals not currently used at DOE facilities were evaluated in this study. Environmental and physical type tests stressed the seals under two broad categories: 1) handling durability; and 2) tamper resistance. Specific tests included pressure sensitive seal testing (peel test, shear test, and solvent test), loop seal testing (mechanical drop and pull test, and humidity test), and individual testing (vibration test, shock test, and abrasive test).
Results (if applicable)	Results provided comparative ratings for the various seals. In the environmental tests there were no negative effects on the seals.
Implications	The report makes recommendations for using currently available seals, and describes a new tamper-indicating technology.

Study details	Horton, 1993[125]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Equipment evaluation: experimental testing
Aims/ Objectives	To report an evaluation of seals used as tamper-indicating devices at Department of Energy (DOE) facilities.
Description of study and methods	A survey was first done to establish what seals manufacturers were using. Then a test plan was developed to measure the seals against requirements. Environmental and physical type tests stressed the seals under two broad categories: 1) handling durability; and 2) tamper resistance. Specific tests included pressure sensitive seal testing (peel test, shear test, and solvent test), loop seal testing (mechanical drop and pull test, and humidity test), and individual testing (vibration test, shock test, and abrasive test).
Results (if applicable)	Results provided comparative ratings for the various seals. In the environmental tests there were no negative effects on the seals.
Implications	The report makes recommendations for using currently available seals, and describes a new tamper-indicating technology.

Study details	Hulme 1979[161]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Equipment or process evaluation
Aims/ Objectives	To evaluate a new subroutine of SAFE called ADPATH.
Description of study and methods	Evaluation of ADPATH to find single-target theft and sabotage paths (adversary paths) in a network model that is considerably improved. ADPATH also makes use of the latest results on implementation of basic pathfinding algorithms by computing the adversary path segments with a faster and more storage efficient shortest path algorithm.
Results (if applicable)	Tables are given to summarise ADPATH's performance on problems of various sizes.The size and location of START nodes makes essentially no difference. Given a list of sabotage and/or theft targets and appropriate guard-response times, ADPATH calculates an adversary's minimum interruption probability path for each target. These are paths that minimise the adversary's probability of being detected while the guards still have time to respond to an alarm and interrupt the theft or sabotage.
Implications	Unclear if any implications for the NHS.

Study details	Hulme, 1986[126]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model
Aims/ Objectives	To present a network model which allows analysts to study the relative weaknesses in a (nuclear) facility safeguard system.
Description of study and methods	The method uses a network weighted with delay times and detection probabilities to model a facility and its safeguard system. For any sabotage or theft target and its guard-response time the solution algorithm calculates an adversary's minimum-interruption-probability path (using nodes and arcs). Such a path corresponds to a relatively good route for the adversary and indicates where improvements can be made in the barrier and alarm systems.
Results (if applicable)	As an example of the efficiency of the polynomial run time algorithm, 30 sabotage and 30 theft paths were found in about one second of CDC 7600 run time for a realistic reactor site model having 310 nodes and 1592 arcs.
Implications	Only relevant if there are areas in a hospital that are high-security. The study is nearly 20 years old.

Study details	Hulme, 1980[127]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model
Aims/ Objectives	Not applicable
Description of study and methods	POST is a subroutine which a safeguards analyst may use to find multiple-target sabotage paths through a fixed-site facility. This subroutine accepts the same weighted digraph facility model as does ADPATH, the single-target adversary path code. Given a list of potential starting nodes and a list of one set of target nodes together with their respective guard-response times, POST computes an adversary's minimum interruption probability path. This path begins at one of the starting nodes and passes through all of the given target nodes in such a way as to minimise the adversary's probability of being detected while the guards still have time to respond to an alarm and interrupt the sabotage.
Results (if applicable)	No results presented.
Implications	No implications (especially for the NHS) presented.

Study details	Jaeger, 1995[128]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	To demonstrate a site-independent system (Project Straight-Line) to monitor stored nuclear material and integrate the collection, processing and dissemination of information regarding this material. The safeguards and security (S&S) goals of this project include data transfer of information on nuclear material to appropriate users to enhance S&S, continuous on-line accountability, reduction of hands-on access to nuclear materials, incorporation of information security technologies and early detection of tampering or unauthorised material movement.
Description of study and methods	The paper addresses threat considerations, S&S requirements, S&S objectives, and issues for the Straight-line project. S&S features and benefits of this project will be discussed with respect to existing item monitoring systems and/or other material tracking systems being developed.
Results (if applicable)	None stated.
Implications	None stated.

Study details	Johnston, 1995[129]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Laboratory testing
Aims/ Objectives	As part of a comprehensive project on vulnerability assessment, 79 different passive tamper-indicating seals were examined.
Description of study and methods	A total of 91 different successful attacks were developed for 79 different types of seals. Types of seals used in the experiment were plastic loop (15), wire loop (4), metal cable (13), metal ribbon (10), bolt type (7), fibre optic (2), adhesive tape (27), and other (1). A successful attack on the seal was defined as opening the seal, then re-sealing it or replacing it with a counterfeit such that the entry or tampering goes undetected. Successful attacks were of 3 types: Type 1 where tampering will not be detected if the usual inspection process is followed; Type 2 where tampering will not be detected even if unusual (but low-tech) inspection occurs; and Type 3 where the tampering cannot be detected even if the most advanced post-mortem analysis is done.
Results (if applicable)	Only demonstrated attacks were reported. Of the 91 demonstrated attacks, 37 were classified as Type 1, 42 as Type 2, and 12 as Type 3. The time to successfully complete the attacks ranged from three seconds for three of the seals to 125 minutes for the most difficult. The mean time was 5.7 minutes. There was little correlation between the cost of the seal and defeat, or between the defeat time and type of defeat.
Implications	The authors state that this is the most comprehensive vulnerability assessment of passive seals ever undertaken. The major finding of this work is disturbing: All the tamper-indicating seals examined can be defeated quickly, using low-tech methods available to almost anyone. For most of the attacks, minor modifications to the seal would substantially increase the difficulty of an attack. Most seals would also benefit significantly from changes in the manufacturer's suggested protocol for use and inspection. Very useful study.

Study details	Kennedy, 1977[130]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Speech about safeguards systems
Aims/ Objectives	To describe and examine the nature of the US safeguards systems. The article considers how the US is organised to develop and apply safeguards and some methods and techniques for assessing the effectiveness of safeguards systems. The means for bringing US knowledge to the attention of other nations that are similarly concerned is also discussed.
Description of study and methods	No study was undertaken.
Results (if applicable)	The authors state that there are three elements of safeguards systems: 1) material accountability; 2) material control; and 3) physical protection. Developing and implementing safeguards are done at government-owned or operated facilities and private facilities licensed by the US government. Two government agencies are responsible: the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). In assessing the effectiveness of safeguards, the authors state that in over two decades of operating US nuclear facilities no member of the public has suffered harm from theft, diversion, misuse, or sabotage of safeguarded nuclear materials. However, it is difficult to assess the overall effectiveness in any more precise way. Some methods of assessing the threat to, and effectiveness of, the safeguards systems were presented.
Implications	ERDA and NRC play leading, though somewhat different, roles in achieving the national safeguards objective. The effective deployment of safeguards systems requires that the work of the two agencies be closely coordinated. A number of evaluation techniques are underway to produce more effective safeguards systems and these should be widely disseminated in the US and overseas. This paper presents work almost 30 years old. Many of the processes mentioned and facts presented are out-of-date.

Study details	Kjeldgaard, 1991[131]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To present the analytical methodology developed by the Sandia National Laboratories Production Risk Evaluation Program (PREP) which provides a logical method for identifying industrial sabotage targets from a system perspective.
Description of study and methods	The US DOE intitated PREP to assess quantitatively the potential for serious production disruption as the result of random failures, accidents, natural disasters or sabotage at its facilities. The procedure incorporates both network and fault tree models that identifies production vulnerabilities. For each production step, a steady-state flow model computes the 'critical time', which is the maximum period a step can be shut down without preventing the system from achieving production goals. The critical time is then used in fault tree analysis to determine the failure modes that can stop the process for longer than this period. Modular logic modelling is used for constructing the fault trees. Equipment restorable within its critical time need not be considered critical even though it may perform significant work.
Results (if applicable)	PREP analytical methods provide a structured, systematic approach to the identification of industrial sabotage targets in a manufacturing system. The analysis here demonstrates that with proper planning both security and system reliability can be improved through the use of appropriate consequence mitigation measures.
Implications	The PREP models can be used to identify those plant areas to which a saboteur would need to gain access. A security strategy using graded protection based on a PREP analysis potentially could reduce security costs. PREP methods also provide quantitative insights to develop protection measures that do not infringe upon the liberties of personnel or complicate work practices.

Study details	Koski, 1998[132]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	To describe some proposed closure methods with shape memory alloys for radioactive material packages. These properties can be used to create a closure for radioactive materials packages that provides for easy robotic or manual operations and results in reproducible, tamper-proof seals.
Description of study and methods	Properties of the shape memory alloys are first summarised, then some possible alternative sealing methods discussed and finally results from an initial proof-of-concept experiment described.
Results (if applicable)	The proof-of-concept tests demonstrate the feasibility of the shape memory alloy closure approach.
Implications	Since closure rings are available from vendors in sizes up to 100mm diameter, the approach could be applied to a wide range of radioactive material packages. All parts necessary to engineer closures based on the shape memory approach are currently commercially available. A potential advantage of the shape memory closure approach is that the engineering necessary to assure a tight seal is considered during the package design and testing phase, so that when used in the field, closure integrity does not rely on the expertise or training of personnel that must perform detailed tasks such as torquing of bolts in a particular sequence. A US patent may be pursued.

Study details	Little, 1982[133]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Mathematical modelling
Aims/ Objectives	To apply Monte Carlo modelling of the neutronics of a lead slowing down time assay device
Description of study and methods	Feasibility study to determine the energy resolution function and flux profile of neutrons slowing down in a lead assay device. The resolution and flux inside the RPI lead assembly were modelled using Monte Carlo calculations. Future calculations are planned in which a full-sized pressurised water reactor fuel assembly will be modelled.
Results (if applicable)	The resolution function has been parameterised for the RPI homogeneous lead assembly and is slightly better that the Bergman et al. prediction above about a few keV. Calculation of the energy dependence of the neutron intensity is in excellent agreement with the measured value over the energy range from 1 to 10(5) eV.
Implications	The results indicate that the useful range of the slowing down time assay device for homogeneous lead is a few tenths of an electron volt to >20keV.

Study details	Luna, 2000[166]
Country of publication	USA
Topic category	NUC
Focus of research	Emergency planning
Type of study or article	Simulation: computer models
Aims/ Objectives	A comparison of results from two spent fuel sabotage source term experiments (SNL and GRS).
Description of study and methods	The experiments were conducted in New Mexico, USA in 1981. Two potential sources of relevant source term data are reviewed and shown to provide consistent information which leads to stated values of respirable surrogate spent fuel aerosol released from the cask per gram of surrogate fuel matrix disrupted by a sabotage attack using a high energy density device (HEDD).
Results (if applicable)	Using a respirable spent fuel to respirable surrogate conversion factor of 3 enables estimation of the spent fuel respirable source term from the experiments reviewed.
Implications	The results of the SNL and GRS test programmes were consistent and provide a relatively straightforward empirical method to estimate respirable release from HEDD attacks on spent fuel casks.

Study details	Maimoni, 1978[134]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Literature review (non-systematic)
Aims/ Objectives	To review the current status of the Lawrence Livermore Laboratory (LLL) programme for Material Control and Accounting Systems assessment within the nuclear power industry. Purpose of the programme is to provide a means of testing compliance with improved regulations.
Description of study and methods	Takes an integrated approach to assess many of the functions normally assigned to physical security, including deceit and tampering. Concerned in particular with timely detection of material diversion by insiders. Analysis explicitly considers deceit and tampering with safeguards system components. Unclear exactly what they did but appear to have tested systems using a model.
Results (if applicable)	Target identification step points up some intrinsic vulnerabilities of the system that would be easy to change during plant design (see Implications).
Implications	Potential material removal nodes could be made less vulnerable by the addition of check valves. These valves would require extra effort and tools on the part of an adversary. Another way to reduce the plant vulnerability is to use materials that are intrinsically less desirable to an adversary.

Study details	Modarres, 2002[135]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Simulation: computer models
Aims/ Objectives	To examine risk assessment approaches to nuclear plant security assessment.
Description of study and methods	Discussion of how a risk-based method should be implemented. They should use a plant probabilistic risk assessment (PRA) to identify important physical locations that house risk-significant systems, structures and components (SSCs).
Results (if applicable)	Locations with high risk potential can then be better monitored using security alarms, human guards, metal detectors, and other protective measures. Areas with small risk impact should receive less security attention. The effects of sabotage on multiple adjacent locations may also be considered and ranked using a risk-based importance measure.
Implications	While this systematic approach provides a significant amount of insight into the best use of resources and prevention, when supplemented with the traditional defense-in-depth thinking, increased protection and security may be provided. Other sources of radioactivity such as the spent fuel pool may need similar analyses.

Study details	Moennich, 1978[136]
Country of publication	Germany
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Computer / theoretical modelling
Aims/ Objectives	To evaluate a domestic safeguards system providing adequate assurance against theft of special nuclear material (SNM) and sabotage by insiders designed for a reference Zero Power Plutonium Reactor (ZPPR) facility.
Description of study and methods	The safeguards system consists of several components. The facility is divided into control areas (CA) which provide physical containment. Successful containment is assured by an added-on Continuous Controllable Containment System (CCCS). The CCCS is supplemented by a Material Control System (MCS) providing material balance discrepancies by Non-destructive Assay (NDA) instrumentation and remote monitoring equipment.
Results (if applicable)	Each of the components of the safeguard system is described but no implementation is presented.
Implications	No implications are presented.

Study details	Moormann, 1995[137]
Country of publication	Germany
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Research overview: laboratory and computer simulation
Aims/ Objectives	To present previously unpublished safety analyses of very severe HTR air ingress events with graphite oxidation as the main point of effort.
Description of study and methods	An overview of several safety analyses for nuclear reactors. The main tool in the safety analyses was the testing simulator code REACT/THERMIX
Results (if applicable)	It was found with REACT/THERMIX that air ingress in case of a closed (gas tight) containment has no significant safety relevant consequences due to the limited amount of air, provided CO-explosions do not destroy the building and do not support by that destruction an additional air flow from the environment. Sensitivity studies indicated that chemical kinetic data are not on the critical path with respect to calculation of air ingress consequences. Also, the results are not very sensitive with respect to the distribution of chemical reaction enthalpies on solid and gas. Significant uncertainties were found in the field of 'local burning' with respect to the SIC-behaviour of irradiated coated particles in case of air ingress and for the consequences of massive corrosion induced geometrical changes in the core area.
Implications	The author states that modelling of air flow into the core depending on leak conditions requires some additional examinations.

Study details	Moul, 1984[138]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Consensus guidelines
Aims/ Objectives	A study was performed by a team of analysts relative to licensing practices and the role of security as they relate to safeguards during safety-related emergencies (SREs).
Description of study and methods	The authors conducted a literature search, site visits to representative nuclear reactors and analysis of the regulatory and licensee planning bases. Problems relating to security actions during SREs were examined primarily in the following areas: organisation for response, planning, training and qualification, equipment, procedures employed, facilities, and preparation for safeguards against sabotage during an SRE.
Results (if applicable)	Recommendations were made as to how improvements could be made in the regulatory approach, and in licensee planning and procedural mechanisms as they relate to the subject matter under examination. Specific issues addressed were: regulatory, organisational, training, security, communications, and equipment and facilities.
Implications	Licensees should take steps to improve planning procedures, training, and organisational controls necessary to assure an adequate security response during an SRE, and to assure that emergency response and safeguards contingency planning efforts are co-ordinated. Likewise, the interaction between safety and safeguards should be given a high priority to assure that responses by the two disciplines are complementary, particularly during an SRE. The results of the study also had implications for the safety/safeguards interface problem currently under review by the NRC.

Study details	Musyck 1981[164]
Country of publication	USA
Topic category	NUC
Focus of research	Detection
Type of study or article	Description of seals
Aims/ Objectives	To evaluate the manufacture of prototype seals following the channels of miniaturisation and cryptography. The study also looks at the possibilities of a third method using an auxiliary non-electronic seal.
Description of study and methods	Describes miniaturisation briefly and cryptographic seals in much more detail, focussing on a cryptographic seal which the author has constructed.
Results (if applicable)	The cryptographic method with keys is generally considered to be the most secure electronic seal provided the encryption number is large enough. The author's own seal worked best with 38 or 42 figures.
Implications	Probably no implications for the NHS as the paper is more than 20 years old

Study details	Myers, 1995[139]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Discussion paper
Aims/ Objectives	Describes the Mobile Detection, Assessment and Response Exterior System (MDARS-E)
Description of study and methods	MDARS-E is a highly secure autonomous intrusion detection system using robotic technology to protect high dollar and sensitive assets and perform a physical audit of inventory on a daily basis. MDARS consists of an autonomous interior security robot and an autonomous exterior robot. Discusses: requirements, system design, platform, navigation, obstacle avoidance, intruder detection systems, lock/ inventory monitoring, communications, system electronics, command and control. Presents a programme schedule.
Results (if applicable)	No results presented.
Implications	Security system: probably of limited relevance to the NHS.

Study details	Parsons, 1977[140]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Theoretical computer model
Aims/ Objectives	To discuss the system design concepts of tamper and radiation resistant instrumentation, including a brief description of the tamper and radiation resistant features, the preliminary test results, and the significance of the work.
Description of study and methods	A radiation and tamper-resistant instrumentation system featuring time domain reflectometry (TDR) has been developed and tested. The TDR technique provides continuous monitoring of liquid level, sensor probe operation, and interconnections between the vessel and the TDR instrument to detect abnormal changes which signify diversion or diversion attempts.
Results (if applicable)	Preliminary test results demonstrate that the TDR liquid level measurement resolution is dependent on the instrument horizontal scale setting with the most sensitive scales yielding the best accuracy. For a vessel possessing a liquid height of 6 feet, the TDR measurement error is approximately 0.1%. The differential pressure measurement error is approximately 0.06%. The overall measurement error is less than 2%, a figure within the guidelines established for measuring SNM in the nuclear fuel cycle.
Implications	This technique provides the safeguards inspector and the industry with a new approach for obtaining accountability data without loss in accuracy. The system advantages are that it possesses a tamper-resistant probe and data link, and provides all the necessary accountancy measurements with a single vessel penetration.

Study details	Paulus, 1994[141]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical models
Aims/ Objectives	To present two complementary analysis tools: ASSESS (Analytic System and Software for Evaluation of Safeguards and Security) and SEES (Security Exercise Evaluation Simulation)
Description of study and methods	Describes the two models.
Results (if applicable)	ASSESS analyses all possible paths of attack on a target and, assuming that an attack occurs, ranks them by the probability that a response force of adequate size can interrupt the attack before theft or sabotage is accomplished. A Neutralisation module pits, collectively, a security force against the interrupted adversary force in a fire fight and calculates the probability that the adversaries are defeated. SEES examines a single scenario and simulates in detail the interactions among all combatants. Its output includes shots fired between shooter and target, and the hits and kills. Whereas ASSESS gives breadth of analysis, expressed statistically and performed relatively quickly, SEES adds depth of detail, modelling tactical behaviour. ASSESS finds scenarios that exploit the greatest weaknesses of a facility. SEES explores these scenarios to demonstrate in detail how various tactics to nullify the attack might work out.
Implications	Without ASSESS to find the facility weaknesses, it is difficult to focus SEES objectively on scenarios worth analysing. Without SEES to simulate the details of response vs adversary interaction, it is not possible to test tactical assumptions and hypotheses. Using both programs together, vulnerability analyses achieve both breadth and depth.

Study details	Paulus, 1988[142]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model
Aims/ Objectives	To discuss the BATLE computer program which carries out vulnerability analysis of security forces stopping or preventing theft or sabotage of special nuclear material at a nuclear site.
Description of study and methods	Probability of neutralisation (of an attack force), P(N), estimates the likelihood that security forces will win given that security forces interrupt the attackers and begin an armed engagement. Brief Adversary Threat Loss Estimator (BATLE) calculates P(N). BATLE was developed for the Nuclear Regulatory Commission in 1980. This paper describes a total repackaging of BATLE, the Threat Neutralisation Model. New features and capabilities are highlighted.
Results (if applicable)	BATLE works with other vulnerability assessment tools, calculates the probability directly and quickly and runs on PCs. Repackaging provided a more friendly user interface, sensitivity studies, graphical output and operation under Microsoft Windows.
Implications	This tool will allow analysts to gain useful insights into the neutralisation aspect of site security with a modest outlay of time for problem preparation and calculations.

Study details	Paulus, 1993[143]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To analyse the vulnerability of nuclear materials to theft or sabotage using two different computer programmes.
Description of study and methods	Since 1989, Department of Energy facilities used a computer programme called ASSESS to analyse vulnerability of nuclear materials to theft or sabotage. During the preceding year, Sandia National Laboratories added a new programme, SEES, to enhance the assessment. The programmes are tested on a hypothetical facility.
Results (if applicable)	ASSESS and SEES are complementary. Whereas ASSESS gives breadth of analysis, expressed statistically and performed relatively quickly, SEES adds depth of detail, modelling tactical behaviour.
Implications	Using both programmes together, vulnerability analyses achieve both breadth and depth.

Study details	Richter, 1991[144]
Country of publication	Luxembourg
Topic category	NUC
Focus of research	Intervention
Type of study or article	Equipment evaluation: Field tests
Aims/ Objectives	To prove the functional performance and reliability of the tamper-resistant TV link (TRTL) under real facility conditions, to collect practical experience in a plant with regard to the appropriateness of the system design and to enhance the system performance by introducing improvements on the basis of the test results.
Description of study and methods	The IAEA, Euratom and the French and German Support Programmes shared the responsibilities for the field test. The TRTL developer specified the technical requirements for the field commissioning of the TRTL in the T0 facility and the IAEA made provisions for installation and test requirements of the TRTL.
Results (if applicable)	The TRTL was connected to CONSULHA on October 13, 1989 and worked until June 13, 1990. During this period the CONSULHA system was in tests and commissioning. Disturbances like video linearity problems, power failures, loss of video signal, interferences etc were recorded by the TRTL. The test results of the TRTL have been used to enhance the performance of the TRTL.
Implications	Can't see any implications for NHS.

Study details	Rountree, 1983[145]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Theoretical model
Aims/ Objectives	The SECURity Officer Response Strategies (SECURORS) technique is applied to a nine-level generic nuclear power plant to determine security officer deployment locations within the facility subsequent to detection of adversary intrusion.
Description of study and methods	Extensive use is made of the facility layout drawings, facility region information, and pathfinder critical path results readily available from the Safeguards Automated Facility Evaluation (SAFE) analysis of the nine-level facility. An additional pathfinder analysis using both the deterministic and the stochastic pathfinder routines from SAFE has been conducted and the results compared to the SECURORS result. The SECURORS approach provides a method for determining security force deployment locations to interrupt sequences of adversary actions which could lead to radioactive release. The security officers are deployed throughout the facility in response to a general alert to intercept the adversaries at points along the adversary intrusion paths. This general deployment approach is in contrast to a response to the specific area(s) where the alarm or intrusion occurred.
Results (if applicable)	Examination of the critical intrusion paths and vital areas within specific sabotage combinations indicates the more vulnerable areas. The SECURORS results and the pathfinder results are compared and found to agree and be highly complementary.
Implications	Since the SECURORS method utilises information from the SAFE methodology it is recommended that a SECURORS analysis be conducted in conjunction with a SAFE analysis.

Study details	Rountree, 1983[146]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention
Type of study or article	Theoretical model
Aims/ Objectives	Addresses the problem of protecting a large number of nuclear power plant areas by a limited security resource.
Description of study and methods	Integer programming
Results (if applicable)	Results for a nine-level generic nuclear power plant illustrate the determination of groups of areas to protect to prevent plant sabotage and the assignment of security officers to optimise plant protection.
Implications	Not clear. Only a short conference abstract.

Study details	Rowland, 1983[147]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Theoretical computer model
Aims/ Objectives	To develop the TASK computer model, to provide an optimal Target Assignment for Security officers to K targets.
Description of study and methods	The model is based on a probabilistic formulation which assumes that only a limited number (N) of security officers are available and that a large number of vital areas are to be protected against sabotage. Starting from given initial positions within a nuclear facility, the security officers respond to an alarm according to a systematic plan which maximises system protection against sabotage by an adversary selecting any link in the system for the point of attack. An adversary attacking at some point other than the weakest results in an even larger system protection. The TASK model determines optimal assignments by forming linear extrapolations from data obtained from the results of independent assignments and identical assignments. Modifications are performed to accommodate multiple security officers with overlapping time assignments. The TASK model is applied to a hypothetical nuclear facility containing a nine-level building. Minimal protective sets are formed by including all Type I vital areas and at least one vital area from each Type II combination. One set of possible target assignments was determined by selecting a minimal protective set having 16 targets (vital areas).
Results (if applicable)	The TASK model yielded a system protection of only 0.49 and 0.54 for 8 and 9 security officers, respectively. A second set of possible target assignments was selected by aggregating targets to allow only 10 targets. The TASK model determined optimal assignments for this case to provide a system protection of 0.77 for 8 and 0.85 for 9 security officers.
Implications	The aggregate target strategy enables the TASK model to assign limited numbers of security officers for a much improved system protection.

Study details	Russell, 1979[168]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Database analysis
Aims/ Objectives	An assessment of the nature and likelihood of attempts at industrial sabotage and theft of nuclear fuel directed against a hypothetical US nuclear power station, and the methodology used to quantify the outcome (probability of success).
Description of study and methods	A statistical analysis has been performed on a proprietary database of worldwide terrorist acts against utilities, particularly electric utilities. Only significant incidents were included and acts by criminal elements were excluded. There were 192 incidents against utilities recorded between January 1 1970 to September 10 1978. From the database of the 192 utility attacks a typical composite profile of national and transnational terrorist groups was developed. A threat consequence was then constructed. Evaluations of the outcome of an assault on the nuclear facility were made with the Forcible Entry Safeguards Effectiveness Model (FESEM), the Insider Safeguards Effectiveness Model (ISEM), and the Estimate of Adversary Sequence Interruption (EASI) graphics computer programs.
Results (if applicable)	One-thousand run simulations for the fixed facility were conducted with FESEM. For the site attribute assumptions made there is a high probability of sabotage loss with inside assistance, but a moderately lower sabotage loss without inside assistance. Theft losses are negligible. Defender success appears acceptable for an attack force of the size presently deemed credible by the US NRC. Sabotage and theft losses are greatest for air assault (helicopter), followed by land (vehicle), and finally, on foot.
Implications	Details of the calculational methods, key assumptions, and important sensitivities to engagement outcome are yet to be presented.

Study details	Sabuda, 1982[148]
Country of publication	USA
Topic category	NUC
Focus of research	Safety Assessment
Type of study or article	Theoretical model
Aims/ Objectives	Provides detailed application information concerning the SNAP Operating System as well as a detailed discussion of all SOS components and their associated command input formats.
Description of study and methods	The SNAP Operating System is a FORTRAN 77 program which provides assistance to the safeguards analyst who uses the Safeguards Automated Facility Evaluation (SAFE) and the Safeguards Network Analysis Procedure (SNAP) techniques. Features offered by SNAP are a database system for storing a library of SNAP applications, computer graphics representation of SNAP models, a computer graphics editor to develop and modify SNAP models, a SAFE-to-SNAP interface, automatic generation of SNAP input data, and a computer graphics post-processor for SNAP.
Results (if applicable)	Not applicable.
Implications	None.

Study details	Schechter, 1979[149]
Country of publication	USA
Topic category	NUC
Focus of research	Prevalence (extent of problem) study
Type of study or article	Synopsis of nine interviews
Aims/ Objectives	A series of nine interviews was conducted with recognised experts in the field of institutional internal security, for the purpose of gaining insight into the insider threat to nuclear facilities.
Description of study and methods	The author interviewed top-ranking security officials from a variety of regulatory, research, and commercial enterprises, as well as a leading consultant to private industry. Questions were asked on the topics of internal security, the bases of conspiracy formation, and NRC options for improving nuclear safeguards.
Results (if applicable)	Fundamental problems of internal security covered employee alienation, excessive loyalty to immediate supervisors, failure to consistently enforce security procedures, failure to separate and rotate duties, and a lack of integrity in the janitorial staff. Typical bases of conspiracy formation covered: insiders unwittingly compromised by fellow employees, mutual animosity towards the firm, friendship, mutual greed, psychopathic instigation, outsiders manipulating disgruntled insiders, and outsiders intimidating insiders. Measures for improving the quality of nuclear safeguards included: increasing employee awareness of rules and regulations, reducing employee frustration and alienation, tightening employee screening, limiting single adversary vulnerability, inhibiting conspiracy formation, preventing cover-up of material discrepancies, preventing lax enforcement of regulations by management, improving the reliability of access controls, and improving surveillance capability.
Implications	The interviews provided a number of useful insights for evaluating the insider threat to nuclear safeguards. It appears that an effective set of personnel policies, as well as a strong program of internal controls, are necessary for minimising this threat. It is recommended that the options cited above be carefully reviewed within the specific context of nuclear activity, so as to evaluate their compatibility with operational considerations. This approach represents a substantive step toward assessing a critical problem area which has been dealt with only through speculation in the past.

Study details	Scott, 1983[150]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Field equipment evaluation
Aims/ Objectives	To describe some of the elements that have been installed as safeguard systems and the field tests that have been performed at an operating nuclear reactor facility.
Description of study and methods	The physical protection hardware to counter an insider threat that was chosen for test and evaluation in a realistic operating environment included: 1) an access control portal incorporating positive personnel identification verification (PPIV); 2) several sensor types providing detection of piping intrusion or breach; 3) video motion detection monitoring of typical safety-related equipment; and 4) valve monitoring devices yielding tamper-safe position information.
Results (if applicable)	Access portals: The sum of the PIN and hand geometry failure percentage yields a system probability of false rejection rate of 1.5%. An intermittent problem was encountered with the infrared sensing planes; the IR beams were repositioned to minimise this problem. Piping sensors: evaluation for a 3-month period on sensors installed in a 120ft section of 36inch diameter piping found that alarms primarily were personnel performing normal duties such as dust sampling. Other known sources included vibrations caused by equipment start-up. Video motion detection: closed circuit video motion detection was used to monitor pneumatic valving and a large direct-driven pump. Detection of intrusion attempts into the alarmed column was excellent for both applications. Valve monitoring: six representative manual butterfly valves with three different sizes of Limitorque operators were monitored. Testing is ongoing, but no environmental or functional problems have occurred.
Implications	Physical protection elements to counter insider threat must not impede the safety, operations, and maintenance programs at a facility. The results of the elements tested in this study indicate that such devices are viable candidates for inclusion in systems designed to protect against insider sabotage activities.

Study details	Sheldon, 1985[151]
Country of publication	USA
Topic category	NUC
Focus of research	Detection
Type of study or article	Mathematical analyses
Aims/ Objectives	To investigate the effect of fixture set-ups on the correlations for intact tamper-proof seals on underwater nuclear fuel assemblies.
Description of study and methods	An experiment was performed in which 640 digitised signal amplitudes were obtained with each of ten fixture set-ups. Statistical measurements were obtained for each of the 640 amplitudes. A statistical model was then derived and data for the model was generated by repeated sampling (a bootstrap method).
Results (if applicable)	The experiment was carried out for N=10,000 and the empirical cumulative distribution for the correlation coefficient r was shown in a figure in the report.
Implications	The authors conclude that set-up errors increase the variability of r, and increase the standard deviation.

Study details	Sliva 1996[160]
Country of publication	USA
Topic category	NUC
Focus of research	Detection
Type of study or article	Overview of the development and laboratory testing of several detection devices for containers
Aims/ Objectives	To find more cost-effective methods of securing nuclear materials or related items of high value in storage or transport.
Description of study and methods	The report covers five projects involving the development of optical-based smart structures. These projects include the first demonstration container, the second container for secure video applications, smart windows, the next-generation container with communications, and the large, intermodal smart shipping containers.
Results (if applicable)	In project 1, several fabrication problems were resolved. The electronics package performed as designed and although functionally basic, revealed the possible electronic functionalities that could be built into optical fiber smart structures. The primary limitation to electronically active portable structures continues to be battery life. In project 2, the electronics package performed as designed and although functionally limited, provided the possible electronic functionalities that can be built into the structure. In project 3, at the time of the project end, a precise method of coupling light into the channel waveguides was being developed. All that remained was to create the sandwich structure to protect and hide the channel waveguides. In project 4, a tamper-indicating composite container was designed for the transport and storage of special nuclear material removed from dismantled weapons. The project was terminated before experimental results were obtained. In project 5, several proposals were written, and at the time of this report, one had progressed only as far as funding.
Implications	These methods have implications for the nuclear waste industry and are designed to sense movement or tampering of materials contained in the storage units being investigated. The relevance to the NHS is unclear.

Study details	Strait, 1986[152]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Workshop on theoretical model
Aims/ Objectives	To present the Safeguards Evaluation Method - Insider Threat - a field-applicable tool to evaluate facility safeguards against theft or diversion of special nuclear material (SNM) by non-violent insiders.
Description of study and methods	To ensure successful transfer of this technology from the laboratory to DOE field officers and contractors, the Lawrence Livermore National Laboratory developed a three-part package. The package includes a workbook, user-friendly microcomputer software and a three-day training programme. The workbook guides an evaluation team through the Safeguards Evaluation Method and provides forms for gathering data. The microcomputer software assists in the evaluation of safeguards effectiveness. Workshop students learn how to use the workbook and the computer software to assess insider vulnerabilities and to evaluate the benefits and costs of potential improvements.
Results (if applicable)	This approach to technology transfer has been successful: over 100 safeguards planners and analysts have been trained in the method and it is being used at facilities throughout the DOE complex.
Implications	None for the NHS.

Study details	Tabatabai, 1986[153]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model
Aims/ Objectives	A study to evaluate alternatives to the design and operation of nuclear power plants, emphasing a reduction of their vulnerability to sabotage.
Description of study and methods	The study used estimates of core melt frequency (CMF) during normal operations and from sabotage and tampering events to rank the 25 alternatives. As a convenience for presentation, the 25 alternatives were ranked on the basis of prioritisation categories from NUREG-0933: high, medium, and low/drop priorities. The CMF for normal operations was estimated by using sensitivity analysis of results from probabilistic risk assessments; for sabotage and tampering, by developing a model based on probabilistic risk analyses, historic data, engineering judgement, and safeguards analyses of plant locations where core melt events could be initiated.
Results (if applicable)	Results include the development of a threat model based on historic events and the evaluation of the 25 STAT alternatives. Results indicate that the most effective alternatives focus on wide areas of the plant, increase safety system redundancy, and reduce reliance on single locations for mitigation of transients. Less effective options focus on specific areas of the plant, reduce reliance on some plant areas for safe shutdown, or focus on less vulnerable targets.
Implications	Most acts of damage in power plants were committed by insiders. To deal with this threat, vulnerability should be reduced through increased operating flexibility and surveillance. A second means is to address staff qualifications and access to sensitive areas.

Study details	Vannoni 1988[163]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical model (PREP)
Aims/ Objectives	To evaluate the Sandia National Laboratories' Production Risk Evaluation Program (PREP) which provides a logical method for identifying industrial sabotage targets from a system perspective.
Description of study and methods	To evaluate and assess PREP quantitatively to determine the potential for serious production disruption as the result of random failures, accidents, natural disasters, or sabotage at its facilities. PREP uses fault tree analysis to determine the failure modes that can stop the process for longer than the critical time such a process can be shut down without interfering with the production process.
Results (if applicable)	The PREP models can be used to identify those plant areas to which a saboteur would need to gain access. PREP methods can also be used to establish the quantitative requirements for the measures of: the type and number of products that would need to be stockpiled; the amount by which the production capacity of subsequent processing operations would need to be increased; the amount by which the equipment repair or replacement time would need to be reduced; and the production capability and capacity that would be required for redundant facilities. A security strategy using graded protection could potentially save money. PREP methods also provide qualitative insights to develop protection measures that do not infringe upon the liberties of personnel or complicate work practices.
Implications	Unclear if any implications for the NHS.

Study details	Varnado, 1978[154]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model: fault tree analysis.
Aims/ Objectives	To discuss the use of fault tree analysis techniques to systematically identify: 1. The sabotage events which can lead to release of significant quantities of radioactive materials, 2. The areas of the plant in which the sabotage events can be accomplished, and 3. The areas of the plant which must be protected to assure that release does not occur.
Description of study and methods	Generic sabotage fault trees have been developed for nuclear power reactor plants based upon the fact that many system functions are common to all power reactors. Procedures have been developed to carry the analysis from the generic level through the development of detailed trees for specific plants. The techniques of the application of the generic fault trees are discussed and are illustrated by presentation of selected results for a typical light water reactor. The possible uses of generic models such as the sabotage fault trees in safety analyses are also discussed.
Results (if applicable)	Appears to be just an introduction to a presentation - no results included.
Implications	None presented. Not a full paper, just a long introduction.

Study details	Varnado, 1981[155]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability Assessment
Type of study or article	Theoretical model
Aims/ Objectives	To provide an extensive set of modular logic for various types of nuclear power plant systems including fluid systems, reactivity control systems, electric power systems, control circuits, actuation systems and ventilation systems.
Description of study and methods	Modular logic models were developed to represent the fundamental fault logic for many commonly occurring nuclear power plant features. Procedures were further defined to guide the fault tree analyst through the process of altering and connecting appropriate modular logic models to build detailed fault trees for specific systems. An interactive computer system was used to assemble and alter the modular logic models.
Results (if applicable)	None presented (description of methods only)
Implications	The procedures outlined here can significantly reduce some of the major disadvantages of traditional fault tree analysis methods. The models are reasonably comprehensive and cover most situations that will be found in nuclear power plant systems. However, the modular logic models should be viewed as a starting point for development of system fault logic. Not sure this really fits with sabotage or tampering.

Study details	Varnado, 1978[156]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical / mathematical model
Aims/ Objectives	To discuss the use of fault tree analysis to identify those areas of nuclear fuel cycle facilities which must be protected to prevent acts of sabotage that could lead to significant release of radioactive material.
Description of study and methods	A fault tree is a logic diagram which graphically represents the combinations of subsystem and component faults that can result in a specified undesired event. The undesired event of interest in this study is the release of significant quantities of radioactive material from a nuclear facility. In the analysis, this undesired event is successively developed into combinations of contributing events until primary events terminate each branch of the tree. Each branch of the tree is developed by identifying the immediate, necessary, and sufficient conditions leading to each event. Vital area analysis is also performed where each primary event in the system fault tree is replaced by the location or logical combination of locations where the (sabotage) action can be accomplished. The output of the Vital Area Analysis is a logic equation which identifies the combinations of area to which an adversary must gain access in order to cause a release of radioactive material from the plant. The location equation can be processed further to identify a minimum set of locations the protection of which will interrupt all possible sequences leading to radioactive release.
Results (if applicable)	The vital area analysis procedures have been applied to several light water reactor plants. The number of vital areas identified for a plant ranged from 20 to 40. Of these vital areas, 3 to 7 were Type I vital areas, i.e. single locations from which a saboteur could complete sufficient sabotage acts to cause release. The remainder were Type II vital areas, i.e. areas which must be visited in combinations of two or more. There were approximately 50 to 90 combinations of Type II vital areas from which radioactive release could be initated and millions of combinations of sabotage acts which could lead to release. The entire process of tree development and analysis requires only a few weeks. Improvements being developed for the case will speed the analysis even more.
Implications	The vital area analysis procedures described in this paper provide a disciplined, logical, repeatable method for determining vital areas in nuclear facilities. The results are consistent in form and level of detail for every plant analysed so that uniform criteria can be applied. There are generic sabotage fault trees which make it possible for an analyst with a minimum knowledge of fault tree analysis techniques to develop detailed fault trees for specific power reactor plants. It is likely that vital area analysis procedures will gain greater acceptance within the regulatory process as more experience is gained in their use.

Study details	Wilkey, 1995[157]
Country of publication	USA
Topic category	NUC
Focus of research	Vulnerability assessment
Type of study or article	Theoretical model
Aims/ Objectives	To develop a standard guide for performing vulnerability assessments.
Description of study and methods	Vulnerability assessments are performed to determine the effectiveness of safeguards and security systems for both domestic and international nuclear facilities. These assessments address a range of threats including theft of nuclear material and sabotage, and use an array of methods. Standardisation could increase the efficiency of performance of vulnerability assessments and the ease of validation and reduce the dependency of vulnerability assessment procedures on the specific tools used to perform the vulnerability assessment. Discusses the vulnerability assessment process, concerns with the current process and proposed approach for ASTM standard practice.
Results (if applicable)	The proposed ASTM standard practice should be a generic procedure for performing vulnerability assessments. The standard practice should not be tied to any tool developed to perform vulnerability assessments; however it should be sufficiently generic to be consistent with the use of those tools. The standard should be written so that vulnerability assessments that are consistent with it can be performed with computerised tools or as a table-top exercise. The standard should also be applicable to the entire range of threats. If the standard could be sufficiently generic to be transparent to the threat being addressed, it might be used outside of the nuclear community. However, it should not become so generic that it fails to provide adequate assistance in performing vulnerability assessments.
Implications	Development of an ASTM standard practice for performing vulnerability assessments would be worthwhile. The product, if accepted and used, will provide improved consistency in the vulnerability assessment process and may decrease the cost and effort required for validation. To complete the task it will be necessary to draw on the broad range of expertise available in the nuclear community.

Study details	Winblad, 1987[158]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical computer model
Aims/ Objectives	To present the assessment model 'Systematic Analysis of Vulnerability to Intrusion (SAVI)', a PC-based path analysis model.
Description of study and methods	SAVI can provide estimates of protection system effectiveness (or vulnerability) against a spectrum of outsider threats including collusion with an insider adversary. It calculates one measure of system effectiveness, the probability of interruption P (I), for all potential adversary paths. SAVI can perform both theft and sabotage vulnerability analyses. For theft, the analysis is based on the assumption that adversaries should be interrupted either before they can accomplish removal of the target material from its normal location or removal from the site boundary. For sabotage, the analysis is based on the assumption that adversaries should be interrupted before completion of their sabotage task.
Results (if applicable)	None stated.
Implications	SAVI models a facility protection system and evaluates its effectiveness against specified threats and specified targets. SAVI provides help for the analyst in considering possible upgrades to the most vulnerable paths. The location of the critical detection point on each path is displayed and, prior to this point, the path can be upgraded by adding detectors. A path can also be upgraded by adding delays past this point. Nearly 20 years old.

Study details	Winblad, 1989[159]
Country of publication	USA
Topic category	NUC
Focus of research	Safety assessment
Type of study or article	Theoretical model
Aims/ Objectives	To present the ASSESS (Analytic System and Software for Evaluating Safeguards and Security) Outsider Analysis module.
Description of study and methods	Outsider and the ASSESS Facility Descriptor module together supersede the Systematic Analysis of Vulnerability to Intrusion (SAVI) software package. Outsider calculates P(I), the probability that outsiders are interrupted during an attack by security forces at the facility and P(W), the probability of security system win, and has other features not found in SAVI. Analysts can select intruders from a set of ten reference threats, ranging from well-equipped terrorists to intruders with no equipment at all. New analysis algorithms run 60 to more than 100 times faster. New reports detail how safeguards are defeated at each element in a path and give other data critical to effective upgrade decisions. Outsider takes as input a facility security system defined in Facility and produces intermediate results for the ASSESS Collusion module.
Results (if applicable)	None stated.
Implications	Outsider is the ASSESS module responsible for determining the vulnerability of a facility to potential violent intrusion by outside threats, such as terrorists and extremists. Analysts load facility descriptions created in Facility, choose threat and response force analysis settings, perform analyses using new fast algorithms and review the results in graphical and textual forms. Outsider has faster algorithms, better threat and deceit modelling, accepts larger ASDs and generates more detailed results than SAVI. Together, Facility and Outsider supersede SAVI as state-of-the-art software tools for outsider intrusion vulnerability analysis.

Study details	Wright, 1995[70]
Country of publication	USA
Topic category	NUC
Focus of research	Intervention study
Type of study or article	Equipment evaluation: pre and post-test
Aims/ Objectives	To evaluate numerous prototype tamper tapes adhered to different surfaces under various environmental aging conditions. Exposed tamper tapes were visually inspected and evaluated for tamper resistance to determine the effects of the weathering conditions. A tamper tape is an adhesive-backed label that possesses various tamper-indicating, transfer-resistant or counterfeit-resistant properties.
Description of study and methods	The prototype tamper tapes were based on the patented 'Confirm' tamper-indicating technology. The complete tamper tape consists of a top layer of Confirm bonded to an underlay material (vinyl or polyester) that provides support around three sides of the tamper tape to allow the fragile 'Confirm' to be efficiently applied to a surface. The area where the underlay is not present is known as the 'Confirm' window. The 'Confirm' is made of glass beads embedded in a brittle bonding material. If transfer is attempted, the logo pattern reflected from beneath the glass beads is distorted as the beads are disrupted from the bonding layer. Weathering studies were performed using protoptype tamper tapes applied to surfaces using both pressure sensitive adhesives (PSA) and reactive, rapid-set adhesives. Surfaces for bonding included aluminum, steel, stainless steel, Kevlar, brass, copper, fibreglass/resin with and without gel coat, acrylonitrile butadiene styrene (ABS) plastic, polyurethane-painted steel, polyester fibreglass board, Lexan polycarbonate and cedar wood. Weathering conditions included a QUV cabinet, a thermal cycling cabinet, a Weather-O-Meter, and outdoor exposure at Daytona beach, Florida. Environmental aging exposures lasted from 7 weeks to 5 months. After exposure the tamper tapes were visually examined and tested for transfer resistance. Tamper tapes were also exposed to a variety of chemical liquids including organic solvents, acids, bases and oxidising liquids, to determine chemical resistance and to sand to determine abrasion resistance.
Results (if applicable)	Of the four Confirm materials (1700, 1500 without primer, 1500 with primer and 1300), the Confirm 1300 was the least affected by the candidate rapid-set adhesives, especially the acrylic adhesive. The tamper tapes prepared with the Confirm 1300 also showed less deterioration in appearance and security feature visibilty in comparison to tamper tapes prepared with the other Confirm materials. Adhesion in general was quite good with all of the tamper tapes with one exception, that of the epoxy 1 on lexan with the tamper tapes prepared from the Confirm 1700 material. The epoxy 2 rapid-set adhesive weathered better than the other adhesives on tamper tapes prepared with any of the Confirm materials.
Implications	The overall results of the rapid-set adhesive weathering studies indicated that the epoxy 2 adhesive weathered better than the other adhesives on tamper tapes prepared with any of the Confirm materials.

TOPIC: NUCLEAR TRANSPORT

Study details	Brown, 1985[175]
Country of publication	UK
Topic category	NUT
Focus of research	Emergency planning
Type of study or article	Theoretical model
Aims/ Objectives	A theoretical study of the events following a hypothetical criticality accident to a particular simplified notional design of transport flask. Possible causes of the accident are sabotage, quality assurance failure or accidental very severe impact causing rearrangement of flask components. To examine the situation when criticality occurs during a refill of a PWR flask.
Description of study and methods	The accident is assumed to arise during the refilling of the flask with water, bringing the system to delayed critical. As the water level continues to rise, reactivity is added causing the power to rise and thus temperatures in the fuel, clad and water to increase. Firstly, various neutronics parameters of the system were calculated. Secondly, a computer program which simulates the physical conditions in the flask has been developed.
Results (if applicable)	Results from this computer program have been obtained and are presented up to the point at which boiling first takes place. The most important points which were accomplished in this work were as follows: The calculation of the reactivity of the flask as a function of water height. The calculation of reactivity feedback due to temperature rise in the fuel (Doppler effect) and reactivity feedback due to water expansion. The calculation of axial and radial power profiles in the flask. The development of a computer model to describe transients involving the flask embodying the previous points. The calculation of several results using the computer code with display of these results in graphical form.
Implications	None.

Study details	Resnikoff, 1990[176]
Country of publication	USA
Topic category	NUT
Focus of research	Risk assessment
Type of study or article	Critical appraisal of a theoretical model.
Aims/ Objectives	To critically review the RADTRAN computer model, used to estimate the risks of transporting waste to a high-level repository.
Description of study and methods	The RADTRAN computer code calculates the radiation exposures and health effects under incident-free transport and over all credible accident conditions. RADTRAN also calculates the economic consequences of transportation accidents. The paper critically appraises assumptions about human behaviour and socioeconomic and political assumptions in RADTRAN which may affect the predicted number of health effects and economic costs.
Results (if applicable)	Ignoring high-consequence accidents, human error, sabotage, realistic accident scenarios and recent health effects data leads to an underestimate of potential health effects. Potential economic costs following an accident in a rural area are low compared to a scale-up of the Palomares, Spain clean-up and other estimates. These costs can vary widely depending on the accident locale and whether certain direct and indirect costs are included.
Implications	The authors conclude that the RADTRAN model underestimates the health impacts of transporting high-level waste to the proposed Yucca mountains repository and suggest improvements to the model.

Study details	Sandoval, 1984[170]
Country of publication	USA
Topic category	NUT
Focus of research	Emergency planning
Type of study or article	Theoretical model with preliminary experiments (discussion of)
Aims/ Objectives	To provide experimental data characterising the quantity, physical, and chemical form of fuel released from hypothetical attacks on spent fuel shipping casks. The objectives were limited to: a) evaluating the effectiveness of selected high explosive devices (HED) in breaching full-size spent fuel casks; b) quantifying and characterising relevant aerosol properties of the released fuel; and c) using the resulting experimental data to evaluate the radiological health consequences resulting from a hypothetical sabotage attack on a spent fuel shipping cask in a densely populated area.
Description of study and methods	Subscale and full-scale experiments in conjunction with an analytical modeling study were performed to meet the programmatic objectives. Correlation tests were also performed along with a health effects evaluation.
Results (if applicable)	The data from this programme indicate that the Urban Studies assessments greatly overestimated the impact of malevolent acts directed at spent fuel casks in urban environs.
Implications	This work could be the basis of additional regulatory revisions of the NRC physical protection requirements. In a larger sense, this work can also be the basis of more credible worst-case analyses since it defines the actual result of an event that is well beyond any expectations of cask failures in accident environments.

Study details	Sandoval, 1981[171]
Country of publication	USA
Topic category	NUT
Focus of research	Safety assessment
Type of study or article	Discussion paper
Aims/ Objectives	To evaluate the radiological consequences resulting from the transportation of radioactive materials in urban areas for various types of transportation scenarios, including sabotage.
Description of study and methods	The authors report on a safety assessment by Sandia National Laboratories of spent fuel transportation in extreme environments. Since no experimental data were available for these assessments, the quantity and characteristics of the released radioactive material were estimated assuming anticipated damage to the package and contents and a particular attack mode.
Results (if applicable)	The US Nuclear Regulatory Commission (NRC) reacted to the initial assessment by requiring restricted routing and physical protection measures for US spent fuel shipments pending the availability of credible experimental data supporting or disproving these predictions. The Dept. of Energy has also initiated a programme at Sandia to create an experimental database so as to make realistic and improved human health risk assessment for this area of study.
Implications	This paper lists ongoing data gathering in order to support more informed risk assessments in the transportation of spent nuclear fuels.

Study details	Sandoval, 1982[172]
Country of publication	USA
Topic category	NUT
Focus of research	Emergency planning
Type of study or article	Theoretical model: estimates based on modelling and preliminary experiments
Aims/ Objectives	To generate a preliminary estimate of the health effects and/or consequences resulting from sabotage of spent (nuclear) fuel truck shipments, and to determine experimentally the quantity, size and chemical form of any released material.
Description of study and methods	First task: to evaluate and characterise the effectiveness of several types of high energy intensive devices (EIDs) to aerosolise and disperse spent fuel elements; scaling of the aerosol parameters. Second task: to determine and characterise the release of surrogate material from a 1/4 scale spent fuel cask filled with surrogate fuel. Third task: experiments to determine a correlation between selected radionuclide particulate size distributions produced from disrupted spent fuel and that from surrogate fuel. Experiments involve subjecting actual spent fuel pellets as well as surrogate fuel pellets to scaled EIDs. Fourth task: to perform scaling verification experiments on full scale shipping casks filled with surrogate fuel subjected to full scale EIDs, to provide scaling information on aerosol parameters and release fractions, to allow scaling to full scale scenarios. Fifth task: to perform multicomponent aerosol modelling and dispersion studies to help determine aerosol containment effects, dilution effects and to obtain a better understanding of basic aerosol formation processes in these types of high energy environments. Six major tests using surrogate fuel have been performed in support of the second task and five correlation tests 'to date' as part of the third task. Technical details are available in the paper. Expected health consequences were calculated using the extrapolated release fraction of 0.0065% as the primary input to the consequence reactor safety model called CRAC.
Results (if applicable)	It appears that a correlation between spent and surrogate fuel aerosol parameters is achievable and that it is feasible to relate the release fractions of surrogate fuel to selected radionuclides of spent fuel. Preliminary results of the health consequences analysis indicate that 25 peak latent cancer fatalities and 5 mean latent cancer fatalities are possible. Peak thyroid and bone marrow dose in rems was also calculated as a function of distance from the release point. At a distance of 30m from the release point the bone marrow dose was calculated to be 190 mrem and the peak thyroid dose was calculated to be 100 mrem. At one mile from the release point the peak bone marrow dose was calculated to be 20 mrem and the peak thyroid dose was calculated to be 10 mrem.
Implications	Unclear.

Study details	Sandoval, 1986[173]
Country of publication	USA
Topic category	NUT
Focus of research	Intervention
Type of study or article	Theoretical model
Aims/ Objectives	Evaluating the effectiveness of selected high energy devices (HED) in breaching full scale spent fuel casks, quantifying and characterising relevant aerosol and radiological properties of the released radionuclides and using the resulting experimental data to evaluate the radiological health effects resulting from a hypothetical attack on a spent fuel shipping cask in a densely populated urban area.
Description of study and methods	Subscale and full scale tests, in conjunction with an analytical modelling study, were performed to meet the programmatic objectives.
Results (if applicable)	The results of the study indicated: 1. Because the source terms, as measured, never produced the threshold dosage for early fatalities and morbidities, the number of early fatalities and morbidities predicted was zero. 2. The total latent cancer fatalities as a result of initial exposure, particle resuspension and long term exposure to contaminated ground were predicted to be 2/7 (mean/ peak).
Implications	The work could be the basis of credible 'worst case' analyses since it defines the results of an event which is well beyond any cask failure scenarios postulated for severe accident environments.

Study details	Sandoval, 1987[177]
Country of publication	USA
Topic category	NUT
Focus of research	Emergency planning
Type of study or article	Theoretical model: an experimental database
Aims/ Objectives	To estimate the consequences of a hypothetical sabotage attack on a spent fuel shipping cask. Primary objectives were limited to: evaluating effectiveness of selected high energy devices (HED) in breaching full scale spent fuel casks; quantifying and characterising relevant aerosol and radiological properties of the released radionuclides; using the resulting experimental data to evaluate the radiological health effects resulting from a hypothetical attack on a spent fuel shipping cask in a densely populated urban area.
Description of study and methods	A programme was conducted at Sandia National Laboratories for the United States Department of Energy to provide an experimental database. Subscale and full scale tests, in conjunction with an analytical modelling study, were performed to meet the programme objectives.
Results (if applicable)	Because the source terms, as measured, never produced the threshold dosage for early fatalities and morbidities, the number of early fatalities and morbidities predicted was zero. The total latent cancer fatalities as a result of initial exposure, particle resuspension and long term exposure to contaminated ground were predicted to be 2/7 (mean/ peak).
Implications	This work could be the basis of credible 'worst case' analyses since it defines the results of an event which is well beyond any cask failure scenarios postulated for severe accident environments.

Study details	Taylor, 1977[174]
Country of publication	USA
Topic category	NUT
Focus of research	Risk assessment
Type of study or article	Theoretical model
Aims/ Objectives	To predict the radiological consequences of transportation of radioactive material in an urban environment.
Description of study and methods	The discussion of the model includes: health effects from radiation exposure, urban area characterisation, computation of dose resulting from normal transportation, and computation of dose resulting from vehicular accidents or sabotage. The model uses estimated values for several urban parameters such as street widths, building heights, and vehicle speeds and uses the urban parameters plus local meteorological data to compute the radiological impacts of accidents in which radioactive material is released to the environment. The model explicitly addresses unique aspects of urban areas such as high population densities, large structures and diurnal population variations. A grid consisting of cells which are homogeneous with respect to any of the assigned parameters is used to represent the urban area for the analysis. Integrated population radiation exposures and individual radiation exposures are computed across the grid and are converted to expected numbers of health effects.
Results (if applicable)	Preliminary results (from testing on a 100 cell New York city grid) suggest that: 1. The significant contributors to the dose from 'normal' transport are the dose to people in vehicles and the dose to crewmen. 2. The time of day when the shipment occurs is an extremely sensitive parameter and can make several orders of magnitude difference in overall impacts resulting from 'normal' transport of radioactive materials. 3. Buildings significantly limit both 'normal' and accidental radiation exposures. 4. Routing restrictions can significantly alter the total dose ('normal' and/or accident). On a risk basis, the impact of accidents involving radioactive material is lower than the impact of transportation under 'normal' conditions.
Implications	None reported, other than those in the results section.

TOPIC: RESEARCH

Study details	Schulz, 2002[178]
Country of publication	Unclear
Topic category	RES
Focus of research	Discussion paper
Type of study or article	Not applicable.
Aims/ Objectives	To discuss key concepts in defending against deciphering of allocation concealment in randomised trials.
Description of study and methods	Focuses on proper approaches to allocation concealment and to reporting of baseline characteristics. Discusses the importance of allocation concealment, personal accounts of deciphering, what to look for with allocation concealment and what to look for with baseline characteristics. Examples of descriptions of allocation concealment are provided with minimum and expanded criteria for adequate allocation concealment schemes. Refers to the literature throughout.
Results (if applicable)	Results of 4 empirical investigations have shown that trials that used inadequate or unclear allocation concealment, compared with those that used adequate concealment, yielded up to 40% larger estimates of effect. Findings of empirical investigations suggest that investigators sometimes undermine randomisation, but this is rarely documented. Researchers frequently fail to report even the barest of descriptions of allocation concealment. This situation is improving since more medical journals are adopting reporting standards for RCTs.
Implications	Minimum and expanded criteria for adequate allocation concealment schemes: Sequentially numbered, opaque, sealed envelopes. Envelopes are opened sequentially only after participant details are written on the envelope. Pressure-sensitive or carbon paper inside the envelope transfers that information to the assignment card (creates an audit trail). Cardboard or aluminium foil inside the envelope renders the envelope impermeable to intense light. Sequentially numbered containers. All of the containers were tamperproof, equal in weight and similar in appearance. Pharmacy controlled. Indications that the researchers developed, or at least validated, a proper randomisation scheme for the pharmacy. Indications that the researchers instructed the pharmacy in proper allocation concealment. Central randomisation. The mechanism for contact (telephone, fax or email), the stringent procedures to ensure enrolment before randomisation and the thorough training for those individuals staffing the central randomisation office. Not really very relevant - tampering with RCTs.

TOPIC: PSYCHOLOGICAL FACTORS

Study details	Anchor, 1976[179]
Country of publication	Unclear
Topic category	PSY
Focus of research	Prevalence (extent of problem) study
Type of study or article	Survey
Aims/ Objectives	To determine the extent to which avoidance of self-disclosure was as characteristic of the middle sessions of psychotherapy as it is of the initial sessions.
Description of study and methods	Nine therapists and 26 clients were used. Immediately after each weekly therapy session, therapists completed a form that asked them to indicate the extent to which the client emitted self-disclosure verbalisations. 20 tapes and transcripts also were judged by an independent rater.
Results (if applicable)	These data revelaed that in the middle stages of short-term therapy for a university population, clients continue to engage in the highest proportion of self-disclosure during the latter half of the therapy hour.
Implications	The position that there are ways in which psychotherapy sabotage can be reduced was discussed. Not really very relevant.

Study details	Garofalo, 1998[180]
Country of publication	USA
Topic category	PSY
Focus of research	Prevalence (extent of problem) study
Type of study or article	Cross-sectional survey
Aims/ Objectives	To examine the association between sexual orientation and health risk behaviours among a representative, school-based sample of adolescents.
Description of study and methods	The study was conducted on an anonymous, representative sample of 4159 9th to 12th grade students in public high schools from Massachusetts' expanded CDCP 1995 Youth Risk Behaviour Survey. Sexual orientation was determined. Health risk and problem behaviours were analysed comparing gay, lesbian or bisexual (GLB) youth and their peers. Those variables found to be significantly associated with GLB youth were then analysed by multiple logistic regression models.
Results (if applicable)	GLB youth were more likely than their peers to have been victimised and threatened and to have been engaged in a variety of risk behaviours, including suicidal ideation and attempts, multiple substance use and sexual risk behaviours.
Implications	These findings suggest that educational efforts, prevention programmes and health services must be designed to address the unique needs of GLB youth.

Study details	Jack, 2001[181]
Country of publication	USA
Topic category	PSY
Focus of research	Qualitative/ descriptive
Type of study or article	Interview
Aims/ Objectives	To discover what elements of anger expression women identify as most important in their experience.
Description of study and methods	Sixty (60) women underwent semistructured interviews that inquired about the expression of anger and aggression in everyday life. Coding focussed on whether anger was brought into or kept out of the relationship.
Results (if applicable)	Six patterns of bringing anger into relationships or keeping it out were identified and discussed.
Implications	None for this review. Study is of questionable relevance.

Study details	Jasper, 1998[182]
Country of publication	Unclear
Topic category	PSY
Focus of research	Prevalence (extent of problem) study
Type of study or article	Retrospective record review
Aims/ Objectives	To describe the characteristics of a population of adolescent females who demonstrated disturbed behaviour so that testable hypotheses for future research could be generated. To examine whether the prejudices held by professionals working with females stood up to closer examination.
Description of study and methods	Data were collected from the psychiatric case notes of 100 consecutive cases who fulfilled the inclusion criteria selected from a cohort of 287 girls aged 10-18 referred to the service between 1991 and 1997. Criteria for inclusion: looked after by social services, or the subject of an order which gave social services a responsibility to provide services, and the Adolescent Forensic Service had completed an assessment. A proforma was designed to systematically record the following information: socio-demographic data, source of referral, information in referral letter, actual behaviour documented during assessment and in other reports, diagnosis, past history of abuse, school attendance and statements of special educational need. Subgroups were constructed for those demonstrating violent behaviour towards people, past history of abuse, having a current secure judgment and deliberate self-harming behaviour. Comparisons of subgroup with non-subgroup was carried out using chi-square tests.
Results (if applicable)	Not relevant - nothing about sabotage or tampering.
Implications	None.

Study details	van Wijk, 2001[183]
Country of publication	Unclear
Topic category	PSY
Focus of research	Description
Type of study or article	Description of psychological traits
Aims/ Objectives	1. To determine the extent to which psychological instruments could be used to describe the psychological profile of Underwater Sabotage Device Disposal (USDD) operators in the South African Navy. The Advanced Progressive Matrices, 16-Personality Factor Questionnaire (16PF), Self-Directed Search Questionnaire and Rey Complex Figure Test were used. 2. To determine the extent to which the 16PF could differentiate between USDD operators and other clearance divers.
Description of study and methods	Study 1. Participants were all active duty USDD operators (n=22) at a large base. Age range 29-45 years (mean, 35.1 years). All male. Rank ranged from chief petty officer to warrant officer class I. All had 12 years formal school education, were qualified to Clearance Diver Part III and had similar USDD training and exposure. Race and length of service were not recorded. All were medically and psychologically fit for duty. Participation in the study was voluntary (although none refused to participate). Administration of the instruments took place individually, by either of 2 study authors. The full battery of questionnaires was completed in one morning. Study 2: the same group of participants as study 1 were compared with a randomly selected group of 86 active duty clearance divers from the SAN diving branch. Age range 18-44 years (mean 24.49 years). All had 12 years formal education, were qualified to Clearance Diver Part I and were enlisted. All were medically and psychologically fit for duty. The 22 16PF profiles from the first study were compared with 86 16PF profiles of clearance divers, which were drawn from their files.
Results (if applicable)	In study 1, five 16PF factors appeared to be most descriptive of this sample: they were adventurous, assertive, self-assured, emotionally stable and tough minded. These factors appeared appropriate when discussed from an environmental demand perspective. Occupational interests were realistic and social, and operators scored high on the Complex Figure Test. In the second study, two factors showed a significant difference between the two groups. The USDD operators were more adventurous and more assertive which also appeared appropriate when discussed from an environmental demand perspective.
Implications	Unclear as to implications.

Appendix C: Ordered but not arrived (awaiting assessment)

1. Sabotage consequence risk analysis for DoE facilities. *Nuclear Materials Management* 1982.

2. *Risikountersuchungen zu Leichtwasserreaktoren. Analytische Weiterentwicklung zur 'Deutschen Risikostudie Kernkraftwerke'. Bd. 2. Teil 4: Anlagentechnische Untersuchungen (LWR Safety Studies. Analyses and Further Assessments Relating the German Risk Assessment Study on Nuclear Power Plants. Vol. 2. Part 4: Design and Safety Engineering Analyses)*. Freiburg im Breisgau Germany: Institut fuer Angewandte Oekologie; 1983. Report No: REPT-24(2).

3. *Computer model evaluates security system effectiveness*. Washington DC: Department of Energy; 1989. Report No: NTN89-0433.

4. Anchor KN, Sandler HM. Psychotherapy sabotage revisited: the better half of individual psychotherapy. *Journal of Clinical Psychology* 1976;32:146-8.

5. Cluett C, Greene M, Morris F, Rankin W, Weiss C. *Identification and assessment of the social impacts of transportation of radioactive materials in urban environments*. Albuquerque NM: Sandia Laboratories; 1980.

6. Downey R. Criminal tendencies, crime in hospitals. *Nursing Times* 1994;90:46-8.

7. Ericson DM. *Nuclear power plant design concepts for sabotage protection. Vol 2*. Albuquerque NM: Sandia National Laboratories; 1980. Report No: SAND-80/0477/2.

8. Grant FH, Engi D, Chapman LD. *User's guide for SNAP*. Albuquerque NM: Sandia National Laboratories; 1980. Report No: SAND-80-0315.

9. Harris WJ, Johnson CE. Evaluation of process data from existing reprocessing plant instruments shows benefits for safeguarding special nuclear material. In: *3rd Annual Symposium on Safeguards and Nuclear Material Management Proceedings*; Karlsruhe, West Germany. Ispra, Italy: ESARDA, 1981. p. 313-318.

10. Heising CD. Analyzing the reprocessing decision: plutonium recycle and nuclear proliferation. *Nuclear Materials Management* 1978;7:91-110.

11. Kupperman DS, Caldwell WA. *Tamper-revealing ceramic-fiber seal*. Argonne IL: Argonne National Laboratory; 1992. Report No: ANL/ACTV-92/1.

12. Levine MI. *Self-handicapping, other-mitigation, and the narcissistic personality. (dissertation)*. New York, NY: Long Island University, 1999.

13. Rountree SL. *Security Officer Response Strategies (Securors)*. Albuquerque NM: Sandia National Laboratories; 1982. Report No: SAND-82-0410.

Appendix D: Records obtained but unable to extract data (awaiting assessment)

1. Railway safety, HM chief of inspector of railways annual report on the safety record of the railways in Great Britain during 1997/98. Sudbury: HEALTH AND SAFETY EXECUTIVE (HSE) BOOKS; 1999.

Available only on microfiche (RWY)

2. Risks Associated with Nuclear Power: A Critical Review of the Literature; Summary and Synthesis Chapter. WASHINGTON, DC: NATIONAL RESEARCH COUNCIL 1979.

Available only on microfiche (NUC)

3. Andrews WB, Tabatabai AS, Powers TB, Daling PM, Fecht BA, Gore BF, et al. Ranking of sabotage/tampering avoidance technology alternatives. Richland, WA: Pacific Northwest Labs.,; 1986. Report No: NUREG/CR-4462, PNL-5690.

Available only on microfiche (NUC; CAR)

4. Gordon C, Anderson C, Gessell T, Prichard H. Review and integration of existing literature concerning potential social impacts of transportation of radioactive materials in urban areas. Albuquerque, NM: Sandia Laboratories; 1980. Report No: SAND-78-7017 NUREG/CR-0742.

Available only on microfiche (NUT)

5. Kupperman DS, Dorris SE, Sheen SH, Palm RG, Dusek JT. Assessment of tamper-revealing ceramic seals: Argonne National Lab., IL.; 1990. Report No: ANL/ACTV-90/5.

Available only on microfiche (TEP)

6. Shyr L-J, Neuhauser S, Mills S, Massey C. Projected Consequence for Potential Sabotage Events Related to Spent Fuel Shipments. Santa Fe, NM: US Department of Energy; 18 Aug 1999. Report No: SAND99-2138C.

Available only on microfiche (NUT)

7. Edmunds TA. Integrated methodology for sabotage vulnerability assessment: Lawrence Livermore National Lab., CA; 1992. Report No: UCRL-JC-110104; CONF-9207102-53.

Available only on microfiche (NUC)

Appendix E: Case law sources

WESTLAW UK (produced by Sweet & Maxwell)

Includes a case locator facility giving a digest of each case, with history, cases and legislation cited and citing cases, and secondary sources (case commentaries). There is case law coverage back to 1865 and it is searchable by subject. Includes:

- Lloyds Reports
- The Law Reports (Appeal, King's and Queen's Bench, Chancery and Family)
- some of Sweet & Maxwells specialist series (e.g. Criminal Appeal Reports and Fleet Street Reports)
- Smith-Bernal transcripts of unreported cases from 1999 onwards
- Current Legal Information

This resource contains a number of databases including Current Law Cases that provides case summaries and references to the appropriate report series where the full text of the case will be available. Includes summaries of cases reported in newspapers (e.g. The Times, FT, The Independent).

BUTTERWORTHS LEXIS

This is a package of resources put together primarily for the academic market. It includes:

- All England Direct (produced by Butterworths)

  Online version of All England Law Reports covering cases heard by the House of Lords, Privy Council, Court of Appeal, High Court

- All England Reporter (produced by Butterworths)

  Next day digest of new cases, going back to 1997, with links to transcripts and reports in All England Law Reports when available

- *Butterworths Law Direct*

  Case digest can be used to identify cases by name or subject

Other alternative sources are listed below but these do not add anything in terms of content coverage to the resources above.

- **BAILII** http://www.bailii.org/
  Freely available via the Internet. A government website listing all cases
  and legislation from 1996, that has recently added Judgments from the beginning of 2003.

- ***Daily Law Notes*** *(produced by the Incorporated Council of Law Reporting)*
  Daily summaries of significant decisions in the House of Lords, the Privy Council, the Court of Appeal, all Divisions of the High Court, and the European Court of Justice

- **Lawtel** (produced by Sweet & Maxwell)

  Daily updating service that includes case synopses.

- **CaseTrack** (produced by WordWave International)

  Searchable database of transcripts of cases from the Courts of Appeal (Criminal & Civil Divisions) , Queen's Bench Division (Administrative Court/Crown Office List and Commercial Court), Chancery Division, including Patents Court and Revenue Court), Employment Appeals Tribunal

- **Justis.com** (produced by Context Ltd)

  Includes:

  - The Law Reports
  - The Weekly Law Reports
  - The Times Law Reports.