



Chartered  
Institute of  
Environmental  
Health

# Journal of Environmental Health Research

# Aims and scope

## Aims and scope

The Journal of Environmental Health Research is a peer reviewed journal published in three formats; Printed Full Journal, Printed Abstracts and On-Line Journal.

The Journal publishes original research papers, review articles, technical notes, professional evaluations and workshop/conference reports covering the diverse range of topics that impinge on environmental health including: occupational health and safety, environmental protection, health promotion, housing and health, public health and epidemiology, environmental health education, food safety, environmental health management and policy, environmental health law and practice, sustainability and methodological issues arising from the design and conduct of studies.

A special category of paper – the ‘first-author, first-paper’ – is designed to help build capacity in environmental health publications by encouraging and assisting new authors to publish their work in peer reviewed journals. Here, the author’s will be given active assistance by the editors in making amendments to their manuscripts before submission for peer review.

The Journal provides a communications link between the diverse research communities, practitioners and managers in the field of environmental health and aims to promote research and knowledge awareness of practice-based issues and to highlight the importance of continuing research in environmental health issues.

**Editorial correspondence:** Papers for publication, letters and comments on the content of the Journal and suggestions for book reviews should be sent to the Editors by Email, to: [haroldharvey@yahoo.com](mailto:haroldharvey@yahoo.com) and [haroldharvey@gmx.com](mailto:haroldharvey@gmx.com) or via the website.

Details regarding the preparation and submission of papers can be found at the back of this issue and in more detail at [www.jehr-online.org](http://www.jehr-online.org).

### On-line access at [www.jehr-online.org](http://www.jehr-online.org)

The on-line version of JEHR is an open access journal and the current and archived issues may be freely accessed at [www.jehr-online.org](http://www.jehr-online.org).

### Listing on the Directory of Open Access Journals

JEHR is listed, and searchable alongside other quality controlled journals on the DOAJ database and available at [www.doaj.org](http://www.doaj.org).

## Editorial team

### Editor in Chief



**Dr Harold Harvey** has been the Editor in Chief of JEHR for the past seven years. Formerly Director of the Environmental Health Protection and Safety Centre and Associate Head of School of the Built Environment at the University of Ulster. He graduated in environmental health in 1974, holds a masters degree in occupational safety and health, a PhD in environmental health and is a Distinguished Teaching Fellow of the University of Ulster, a Fellow of the Chartered Institute of Environmental Health, a Chartered Member of the Institution of Occupational Safety and Health and a Registered Safety Practitioner. He is external examiner for several UK universities, a visiting professor at the University of Botswana and a member of the African Academy of Environmental Health.

### Editors



**Professor Paul Fleming** is Associate Dean of the Faculty of Life and Health Sciences at the University of Ulster. His specialisms lie within the fields of public health and health promotion and he has lectured, supervised, reviewed and published widely on these subjects. He is a professional consultant to several government bodies and holds chairmanship and membership of a range of government, professional and research committees. He has been an editor of JEHR for the past six years.



**Professor Ian Blair** is Dean of the Faculty of Health at the University of Central England. He graduated in environmental health in 1984. He is a prominent researcher in the field of food safety having been awarded close to £1 million for his research activities, supervised 35 PhD students and published in excess of 100 papers and chapters. His previous academic management roles have included Head of School of Health Sciences and Director of the Health & Rehabilitation Sciences Research Institute at the University of Ulster.

# Editorial team

## Associate editors



**Miss Julie Barratt** is Director of the Chartered Institute of Environmental Health, Wales. She graduated in environmental health in 1981 and has a wide range of practice experience in environmental health. She graduated in law in 1992 and qualified as barrister in 1993. She is legal columnist for the Environmental Health Practitioner.



**Mr Martin Fitzpatrick** is a practising environmental health professional with Dublin City Council currently specialising in environmental protection. He is an advisor, consultant and author to the World Health Organisation and the United Nations Development Programme and has advised on, and managed, environmental health projects in Europe, Indonesia, Latvia, Kazakhstan and Thailand. He was an advisor to the WHO preparatory meeting on the Third Ministerial Conference on Environment and Health, advisor to the Department of Health and Children in the Republic of Ireland and environmental health advisor to Concern International in Banda Aceh following the tsunami disaster. He has been associate editor of JEHR for the past six years and is a member of the Environmental Health Officers Association of Ireland.



**Dr Gai Murphy** is Associate Dean of the Faculty of Science, Engineering and Environment at the University of Salford. She holds a doctorate in zoology and is a member of the 6\* Built and Human Environment Research Institute at Salford University. Her research interests include pest management in the urban environment, the topic of many of her publications. She has a post graduate qualification in teaching and delivers modules on the undergraduate Environmental Health and postgraduate Occupational Health and Safety programmes.



**Mr David Statham** was formerly Director of Enforcement and Standards at the Food Standards Agency. He graduated in environmental health in 1974 and also holds a Master of Business Administration. His current portfolio includes local authority food enforcement, food standards and consumer protection, meat hygiene policy and enforcement and imported food. He is Past Chairman of Council of the Chartered Institute of Environmental Health and former chair of the Food and General Health and the Resources Committees. He is the current chair of European Food Law Enforcement Practitioners Group (FLEP).



**Dr Ken Stewart** is a former local authority director of environmental health and deputy director of the Scottish Centre for Infection and Environmental Health. He has held honorary lecturer, visiting fellow and external examiner positions at several universities. He is a past president of the Royal Environmental Health Institute of Scotland. He is a managing consultant in environmental health and has been an associate editor of JEHR for the past six years.

## Peer review board:

Ms P Allen; Mr G Bannister; Dr S Battersby; Mr D Boland; Dr F Bushell; Dr W Byers; Mr R Cameron; Mr K Carberry; Ms K Casson; Mr J Corkey; Mr A Curran; Dr R Couch; Ms V Donnelly; Mr J C Engelbrecht; Ms N Ford; Dr A Grigorish; Mr P Gray; Dr T Grimason; Dr C Harris; Mr O Hetherington; Mr D Holmes; Mr D Kennedy; Prof G Kernohan; Prof Kusal K Das; Mr V Kyle; Mr P Lehane; Mr M Mohutsiwa; Mr T Maswabi; Ms B Mbongwe; Mr T Moran; Dr Tayser Abu Mourad; Dr M Mullan; Mr S MacIntyre; Mrs A McCarthy; Mr G McCurdy; Mr G McFarlane; Mr T McLernon; Prof J McLoughlin; Ms J Needham; Dr A Page; Mr N Parkinson; Dr S Powell; Ms C Pritchard;; Ms D Rennie; Ms V Meyer; Dr D Skan; Dr D Stewart; Dr E Serap; Dr Jill Stewart; Mr A Sooltan; Prof M K C Sridhar; Mr A Strong; Mr C S Swales; Dr S Tannahill; Mr S Taulo; Dr D Tessier; Ms U Walsh; Dr N Woodfield.

# Contents

<b>Editorial</b>	
Editorial Team profiles	64
Editorial	67
David Statham	
<b>Papers</b>	
Lay perceptions of health, housing and community on the Kent coast, England	69
DR JILL STEWART AND PROFESSOR LIZ MEERABEAU	
Oxidative stress and antioxidants status of occupational pesticides exposed sprayers of grape gardens of Western Maharashtra (India)	81
DR JYOTSNA A PATIL, DR ARUN J PATIL, DR AJIT V SONTAKKE, DR SANJAY P GOVINDWAR	
Distribution pattern of a dengue fever outbreak using GIS	89
C D NAZRI, I RODZIAH, A HASHIM	
The impact of chemical treatments on the wear, gloss, roughness, maintenance, slipperiness and safety of glazed ceramic tiles	97
DR FRANÇOIS QUIRION, ANDRÉ MASSICOTTE, SOPHIE BOUDRIAS, PATRICE POIRIER	
<b>First-time, first author paper</b>	
Risk factors in children's accidents leading to emergency treatment in hospital	111
TRIANAFILLIA T GLANIA, THEODOROS LIALIARIS, GRIGORIOS TRIPSIANIS AND THEODOROS C CONSTANDINIDIS	
<b>Professional evaluation</b>	
Egg-borne outbreak of <i>Salmonella enteritidis</i> (PT6) in a nursing home: the need to continue reinforcing good food handling and hygiene practices	121
DR JULIAN ELSTON, MIKE J WADE, DR ANDERS WALLENSTEN, KATHERINE O'CONNOR	
<b>CIEH funding for research projects</b>	
Criteria and process	129
<b>Book reviews</b>	
Essentials of Toxicology for Health Protection: A Handbook for Field Professionals	130
reviewed by Dr Daniel M Tessier	
Energy and Climate Change: Creating a Sustainable Future	131
reviewed by Dr Philip Griffiths	
<b>Notes for authors and invitation to contributors</b>	132
<b>Invitation to peer reviewers</b>	133
<b>Letters to the editor</b>	133

Please visit [www.jehr-online.org](http://www.jehr-online.org) for information, discussion and access to the electronic version of the journal

## Editorial



**David Statham**  
Associate editor

As I write this editorial, a mother and child are seriously ill in a Welsh hospital following an outbreak of *E Coli* O157 associated with a fish and chip shop in Wrexham. I mention this only because one of the papers in this issue describes a salmonella outbreak in a nursing home caused by problems associated with eggs. This brings into sharp focus the fact that although some real progress has been made in tackling food borne disease, there is still much to do. All too often, outbreaks can be traced to ignorance of the risks, which leads to careless or even foolhardy food handling. Despite the introduction of food safety management systems based on HACCP principles, clearly in many cases the message isn't getting through. This was further highlighted in the report produced by professor Pennington into the outbreak, again of E.Coli in Wales. With environmental health resources as always being at a premium, it is essential that food businesses take responsibility for ensuring the food they serve to their customers is safe and where they fail to do that, they should expect the full force of the law to be brought to bear.

If food borne disease remains a major issue in the UK, then serious epidemic diseases continue to be a threat in many parts of the world, Dengue fever is one such disease, which causes serious morbidity in Malaysia. The ability to trace cases and identify risk factors is key to successfully targeting resources to tackle any infectious disease outbreak, so the techniques described in the paper by Nazri, Rodziah and Hashim could have wider application.

A well established public health principle is that exposure to toxins has impacts on those exposed which may produce acute symptoms or quite commonly chronic ill health in later life. The problems associated with exposure to pesticides, particularly among agricultural workers, have been widely reported, but in a world where higher and higher crop yields are required and the demand for 'perfect' crops by those of us in the Western

World is taken as the norm, it is unacceptable if this can only be achieved, at the expense of the worker's long term health.

Those with long memories will remember that back in the 1980s the World Health Organisation issued a wide reaching policy document entitled "Health for All by the year 2000". A central pillar of that policy was tackling inequalities in health. It was then, and remains so today, morally unacceptable that people born in the wrong countries or to parents from lower social class, or indeed in neglected areas such as English coastal towns, have a lower life expectancy than those born in more favourable surroundings. Rather than eliminating health inequalities as was the aim of the WHO, the gap just gets wider and wider between the haves and the have nots. Perhaps all EHPs should have tackling health inequalities as one of their key objectives and public health authorities, both in the UK and elsewhere in the world, should allocate resources based on tackling this iniquity.

In this issue we introduce a new and special category of paper – the 'first-author, first-paper' – which is designed to help build capacity in environmental health publications by encouraging and assisting new authors to publish their work in peer-reviewed journals. When a manuscript in this category is submitted to JEHR, the author will receive more active and tolerant support by the editors in making amendments before submission for peer review. Triantafillia Glania, a doctorate student in the Medical School at the Democritus University of Thrace, Greece, publishes her first paper in this issue.



# Lay perceptions of health, housing and community on the Kent coast, England

Dr Jill Stewart<sup>1</sup> and Professor Liz Meerabeau<sup>2</sup>

<sup>1</sup> Senior Lecturer, School of Health and Social Care, University of Greenwich

<sup>2</sup> Head of School, School of Health and Social Care, University of Greenwich

**Correspondence:** Dr Jill Stewart, University of Greenwich, Mary Seacole Building, Avery Hill Campus, Southwood Site, Eltham, London SE9 2UG. Telephone: +44 (0)20 8331 8218. Email: J.L.Stewart@greenwich.ac.uk.

## Abstract

Lay perceptions of health inequalities are becoming increasingly important in developing local housing strategies and many coastal areas have attracted recent attention because of high levels of deprivation.

This paper draws from the findings of 14 socio-economically and geographically representative focus groups as part of the wider French British Interreg IIIA project examining health inequalities and health behaviours in South East England and Northern France. Kent coastal areas were identified as being of particular and unique interest, leading to a wider literature review of socio-economic and health inequalities more generally in coastal towns and the effect of geography on health.

Participants in the focus groups particularly suggested that the loss of traditional industries – notably the holiday trade (tourism), but also other local employment – had led to new low-income, deprived communities, including immigrant communities, whose needs often went unmet. Participants identified the changing nature of coastal or seaside housing from guest house to residential living accommodation and the relationship to the benefit system as being of particular concern, affecting both physical and mental health and the wider environment. However, participants also described successful local community-led regeneration solutions which could run alongside new local authority responsibilities to tackle health inequalities.

The focus group findings suggest that lay perceptions are in many ways close to recent governmental research findings which identify the coastal regions as unique environments, some with similar levels of deprivation to inner urban and rural areas and lacking sufficient public investment. The results of this study suggest that the public have additional concerns around housing allocation policies creating marginal coastal communities and how these needs might be addressed.

New strategies need to involve the communities affected. Although this can prove challenging, there is a new range of legislative provisions to tackle complex and multifaceted housing, social, economic and environmental conditions faced by those suffering some of the most acute health inequalities.

**Key words:** *Coast, environmental health, health inequalities, housing, lay understanding, lay perception, seaside.*

## Introduction

Coastal towns remain among the least understood of Britain's problem areas, such as inner city or rural locations, and have historically failed to attract attention or resources. Coastal towns have faced particular challenges since the 1950s with the decline of British tourism (Fothergill in ODPM, 2006; CLG Select Committee, 2007; Weaver, 2007). Many resource and funding regimes have proved non sustainable, as they have not been able to meet the unique needs and requirements covering social, economic and environmental issues of coastal environments.

There are many reasons for multiple deprivation in coastal areas. The decline of traditional employment has led to low wage, low skill economies with seasonal employment based on single industries such as tourism. Age tends to be skewed to the young and old as younger adults migrate outwards. Coastal areas suffer from poor transport and infrastructure and being geographically peripheral, have a restricted catchment area. This has led to high levels of transience, low aspiration and intergenerational poverty and dependence (ODPM, 2006; CLG Select Committee, 2007; Weaver, 2007; Ward, 2007). The Department for Work and Pensions (DWP) also recognises coastal areas as one of nine types of disadvantaged areas in England, citing Hastings as an example. Hastings is affected by both the decline in the seaside holiday industry and the loss of land-based industries, fishing and some manufacturing industries and recognising the conversion of hotels into care homes, cheap bedsits and hostels for homeless people, resulting in a concentration of vulnerable people (DWP, 2004).

Coastal towns account for a disproportionately high percentage of England's deprived areas and many of the South East's most multiply deprived wards are in coastal towns and cities. Disadvantage and deprivation are particularly acute along parts of England's South East (Kent) coast. For example, half of Thanet and Hastings' population is highly deprived, and there is growing evidence of entrenched intergenerational poverty as classified by the Index of Multiple Deprivation (ODPM, 2006). One major problem is that many Kent resorts, which are all very different, lack a specific identity in relation to other coastal areas (such as Brighton) to attract inward public or private investment, even though Kent forms the 'gateway' from England to France (ODPM, 2006). This coastal deprivation is exacerbated by the fact that other Kent locations are thriving and prosperous, including growth areas such as the Thames Gateway and Ashford (ODPM, 2006).

Thanet in northeast Kent (comprising Margate, Broadstairs and Ramsgate and villages) has been recognised as particularly deprived, having lost both tourism and industry and with a concentration of vulnerable people compounded by its large care industry attracting those from outside, and many London Boroughs have relocated people on their housing and care lists to this seaside location (ODPM, 2006). The Government's Social Exclusion Strategy Unit recently reported that:

*"Following the collapse of English seaside tourism, Sandytown in Beachville, Thanet (Kent) has seen its redundant hotels turned into hostels for the homeless, cheap bedsits or care homes. The concentration of vulnerable and transient residents, including refugees and asylum seekers, elderly people and children in care has severely strained public services and led to tensions between longstanding residents and the new population."*

The situation has been aggravated by the continual 'top up' of vulnerable people into the area, with interventions and resources struggling to deal sufficiently with the new and existing community with its high levels of mental illness, and looked-after children and troubled juveniles, combined with a lack of community facilities, causing social tension (ODPM, 2006).

For the purposes of this paper, 'vulnerable' is used to describe those with socioeconomic vulnerability, including poverty, lack of education, the homeless as well as vulnerability by age, including pregnant adolescents and older people whose health and wellbeing is at risk. Edelman and Mandle (2006) question whether these groups' needs – including lack of control, disenfranchisement, victimisation and powerlessness – are addressed or even understood. ODPM (2006) use the term to identify adults and children who are unable to meet their own everyday needs because of physical or mental condition or because of their situation, such as homelessness, and therefore need to receive service support. ODPM adds that vulnerable people may move to the coast voluntarily, or they may be placed there by another authority and that there are considerable costs associated with this 'social dumping', aggravated by its sometimes transient nature.

A particular challenge is that of addressing coastal housing stock, which has received a growing academic and media interest in recent years. The Communities and Local Government Select Committee Report (CLG, 2007) highlighted a range of housing issues in coastal areas, including lack of affordability (owing to high levels of second home ownership), empty homes but conversely homelessness and disproportionate levels of unsuitable accommodation. The hey-day of the English coastal resort's legacy is mainly one of large Victorian and Georgian houses, which can fail to meet contemporary housing need. This has facilitated the conversion to multiple occupancy, which has in turn enabled a concentration of vulnerable communities in private rented housing within coastal towns, leading to multiple deprivation. Added to this is the rapid physical decay of housing aggravated by years of neglect and erosion from the coastal environment and weathering (English Heritage and Urban Practitioners, 2007).

Essentially, much coastal housing is of poor standard as it was originally designed for holiday lets rather than permanent residential accommodation, with higher numbers of houses in multiple occupation (HMO) than elsewhere. This private sector accommodation has proven (relatively) cheap, although frequently unsuitable, and so has attracted a transient homeless population that has proven to be both an unstable and unsustainable community (ODPM, 2006). Evidence cited in ODPM (2006) reports that particular housing problems in seaside areas include that in 1991, nearly half of all stock was non-decent compared to 33% elsewhere; 6% was unfit compared to 4% elsewhere and 20% fell into the privately rented category, twice the rate of elsewhere, with lower levels of social housing and owner occupation. The Kent Coastal Town Analysis 2002 (cited in ODPM, 2006) demonstrates that most deprivation is at the coast and housing experiences low property values, high levels of absentee landlords and high building repair costs.

## Research methods

This work reports on selected findings of the French-British Interreg IIIA<sup>1</sup> project examining health inequalities and health behaviours in South East England and Northern France. In particular it explores

<sup>1</sup> Interreg IIIA was concerned with European interregional research carried out in Kent, Medway and East Sussex and Nord Pas de Calais, and this particular project sought to support the on-going quantitative research project from the perspective of those affected by health and healthcare policies and to investigate the scope and potential for participative approaches in delivering health and health care improvements through a variety of health agencies delivering health and healthcare needs to the local population.



lay perceptions of health determinants, status and opportunities for health. Part of the work has explored lay views on the changing nature of the English coast and this work has coincided with recent UK government reports, in particular the First and Second Coastal Town Reports (ODPM), 2006 and Communities and Local Government (CLG) Select Committee, 2007). Combined, this usefully reinforces the growing interest in the geography of health ('place' and health) in the public health field and a growing literature on the relationship between health and the social environment (for example, Curtis, 2004; Gatrell, 2001; Gatrell and Elliot, 2009) and the relationship to health inequality, variation in service provision and the effect of migration on health, culture and identity. This paper reports on issues arising in respect of the housing, health and community in coastal areas in Kent, England.

There is a considerable amount of research around explanations for health inequalities, but rather less on what people themselves think explains health and illness (Blaxter, 1997; Popay *et al.*, 2003). Lay perceptions are increasingly recognised as an important factor in helping inform acceptable health promotion policies, although there remain disparities as to how people perceive and express their experience of inequality in relation to their own socio-economic background (Davidson *et al.*, 2007). Research into lay perceptions of health inequalities offers individual and structural insights into causes of health and illness, as well as the opportunity to probe some possible solutions. Such public involvement in decision making is set to become an increasing part of new community based public health policies. The Local Government and Public Involvement Act (2007) places a duty on local authorities and primary care trusts in England to identify the health and wellbeing needs of the population.

Focus groups were used in this research as they can help to reveal lay perceptions of problems and solutions, helping facilitate policies to meet health and health care needs. Fourteen focus groups were conducted in South East England, which aimed to be socio-economically and geographically representative of residents living in Kent, Medway and East Sussex, Brighton and Hove. In order to do this, the Townsend Index was used as this was also used in the French part of the study. Each electoral ward was placed into one of 20 groups based on socio economic status, with group one being the most affluent and group twenty being the most deprived. The groups were then aggregated into tiers. The more deprived wards in South East England discussed in this paper are generally 'pockets of deprivation' as the towns are not

very deprived in relation to England as a whole (Shaw *et al.*, 1999; Vickers *et al.*, 2003). However, there is always a risk that pockets of deprivation in relatively affluent areas may be overlooked.

Each focus group included 6 – 11 participants, with an average of 8, balanced as far as possible by age and gender. Recruitment of participants involved contacting pre-existing groups, and this may mean that there is some overestimation of engagement by the general public, as many recruits were engaged with at least one community group. However, they also know their community closely. Group members addresses were also checked to confirm that they lived in the correct ward. The age range of participants ranged from 17-80 with a preponderance of middle aged and older people: 33% of participants were male and 67% female, so women were over-represented. Participants were also asked to complete a questionnaire to assess whether they were socio-economically representative of the electoral ward in which they lived and this was the case to a limited extent.

Each group session lasted approximately 1.5 – 2 hours at a convenient venue and date and participants' expenses were refunded. Two pilots were conducted on the English side and the results here are from the 14 focus groups in the main study. Each member was advised as to the nature of the focus group, its purpose and practical arrangements and all signed their consent to attend and have their comments recorded and cited anonymously. The proceedings of all focus groups were tape-recorded and transcribed verbatim. The distribution of focus groups is shown in Table 1.0.

Each focus group was structured around four predetermined questions exploring lay perceptions on deprivation and life expectancy in the region. Of particular relevance to this paper, one question focused on the subject of place (or geography) and health. It used two deprivation and inequalities maps of Kent to stimulate both a greater understanding of the subject areas and more in depth analysis of issues surrounding inequalities in health.

Participants were asked to look at two maps of Kent and Medway representing deprivation and life expectancy. They were asked if they had been aware of the deprivation and inequalities in health in the region. Participants were asked for their initial, individual thoughts on the life expectancy and deprivation ratings, which they wrote down on post-it notes, before group discussion around issues arising.

**Table 1.0**  
Distribution of  
Focus Groups

Less deprived	Tier 1	Focus groups 10, 12
	Tier 2	Focus groups 2, 11, 13
	Tier 3	Focus groups 6, 14
	Tier 4	Focus groups 1, 3, 9
More deprived	Tier 5	Focus groups 4, 5, 7, 8

The qualitative study was conducted on both sides of the Channel using the same methodology, but this paper only reports on the English side of this particular study as the findings are unique to the Kent coastal areas.

## Results and discussion

The focus group comments align closely to many observations and issues identified in recent research and participants' understanding of coastal areas was identified as a discrete area for future further exploration.

### The importance of history in coast and health

Participants' initial response was one of surprise that low life expectancy tended to be concentrated around coastal areas. Participants in eight focus groups explicitly commented on coastal areas, and all but one expressed surprise that these areas were generally deprived. The following comments illustrate what many of the focus groups were thinking:

*I was surprised that the low life expectancy is mainly in coastal areas – that was my first thought... I would have thought that in the coastal environment where food is supposed to be that much better, sea breezes and all this should constitute a better lifestyle and from a health point of view, but it doesn't seem to.* (Focus Group 2).

In commenting on the importance of place (coast) on health, some suggested, possibly tongue in cheek, that moving inland may help raise their own life expectancy (for example, Focus Groups 2, 3, 4 and 5). In addition, participants were surprised that coastal areas stood out so clearly as deprived in relation to other parts of Kent, which was generally perceived as a healthy place to live (in particular, Focus Groups 5 and 12).

When asked to explore why life expectancy might be lower in coastal areas, some participants considered that many of these areas had traditionally been seaside resorts which had more recently lost their major source of income, giving way to a rapidly changing and new, deprived community. This was largely seen to stem from the loss of traditional tourism as people tended to travel abroad far more for holidays, leaving English seaside resorts depleted of their traditional tourist activities.

Overall, participants viewed the change in coastal areas from one of buoyant tourism to apathy, which had been developing over a period of time, but particularly since the 1970s. Some participants recounted their childhood experiences of holidays at Kent seaside resorts, when the area was totally different:

*...and my grandparents came on holiday down here, so every year we came down to Margate, Ramsgate or down by the Lido or somewhere to meet, so the whole family, cousins etc all met, and the area was totally different then... Well, it was humming, it was buzzing – I mean this is looking at the early 50s into ...maybe until just about the beginning of the 60s, and then tourism came in and foreign holidays and a better guarantee of sunshine. Coaches stopped coming down for day-trippers so the area... Yes, it has completely changed the area... (All the old resorts)... have all lost the holiday trade.* (Focus Group 5).

Several of the focus groups suggested that the initial problems in coastal decline had come not just from loss of holiday trade, but also from the loss of local industries such as fishing and from the docks and ferry closures (for example, Focus Groups 1, 3, 5, 9), leading to high unemployment and deprivation. Many participants suggested that the government was responsible for the decline, and also for not addressing the decline promptly enough. However, some participants suggested that:

*“it’s not all about government funding – it’s more about private sector... actually there was no money at all in the area in the first place” (Focus Group 5).*

Generally, participants saw decline as multi-factoral, with lower life expectancies in run-down areas and the decline in over-used amenities. A major part of this was seen to be the loss of local industry affecting the breakdown of both family and community (for example Focus Groups 5, 9).

Some participants argued that government policy – in trying to secure new forms of local income for business such as the holiday trade – had in fact been responsible for part of the change toward a new, benefit-dependent community. There was an overall understanding across the focus groups that these coastal areas had shifted from hotels for holidays, to hotels for homeless households as bed and breakfast accommodation for an entirely new clientele. For example:

*So of course a lot of them had to take down the ‘Hotel’ sign because they were no longer actually being what they should be, which is accommodation for somebody looking for somewhere to stay for bed and breakfast or an evening meal. So a lot of the big houses that are now multiple occupation were hotels, that then became benefit places which then finally have crumbled down. (Focus Group 5)*

Another group made a similar observation:

*It’s not good living within sea air! It’s because of the bed and breakfast classes, because it’s a migrant population. Well, in Ramsgate, it always struck me that a lot of the mothers who came into school were slightly depressed, they were down ...and they are not going to live so long, are they? (Focus Group 12).*

There were suggestions that many households were being ‘dumped’ in such areas, causing a concentration of deprived communities leading to high (and frequently unmet) demands on local services. One focus group reported that:

*No, it’s because it’s areas of deprivation. Somebody who lives in those areas has a long history of unemployment and deprivation; also, when you look at the coast, it’s where you have had people who have been dumped on the coast, haven’t you?... Well, because you get young pregnant girls, you get ones who have been in trouble and inner cities have dumped them on the coast to manage by themselves.*

*They get involved in drug taking with various un-savoury people. And also, as far as I understand it, a lot of people with mental health problems – they are dumped on the coast to look after themselves. (Focus Group 9).*

The issue of ‘dumping’ vulnerable households – suggesting a lack of choice and a lack of follow-up support – was reiterated in the Second Report on Coastal Towns (CLG Select Committee, 2007), which stated that traditional English seaside resorts have become run-down ‘dumping’ grounds for inner city problem families, causing rising levels of benefit claimants. ODPM (2006) suggested that Kent coastal resorts have suffered from their proximity to London and effect of London ‘dumping’ since the 1960s and 1970s.

*And also ... particularly in the Thanet area I think ... the London area ships down their teenagers and things like that, who very often are depressed as well and they probably live rough after a while. It’s got a lot to do with it... And the unemployment in... Thanet. (Focus Group 12).*

### Housing and health

Many of the views obtained in this research mirror that of wider research, such as in the case of the interaction between the type of housing in seaside towns and the operation of the benefits system, in particular the availability of a ‘new’ privately rented sector that was previously holiday accommodation. Beatty and Fothergill (2003) for example demonstrated that some seaside towns had attracted the non-employed and unemployed from elsewhere; that many of the unemployed live in rented accommodation and that most of them claim Housing Benefit. (The research also indicated that most of the joblessness in seaside towns is not driven by in-migration, but that is not for debate here).

Although not specifically questioned about housing in this research, housing was raised many times by participants across a range of the focus groups. Participants in Focus Group 9 agreed that: *“Housing is one of the biggest contributors, isn’t it, to poor health...”* and Focus Group 3 suggested that, *“housing is where you live – it’s the most important thing...”* Issues identified by focus groups included affordability, the loss of social housing, allocation policies and the congregation of communities around lower cost housing stock of both UK residents and immigrant communities (for example, Focus Groups 1, 4, 5, 9, 12).

*Well if you look at Cliftonville, like you were saying, the amount of foreigners that are there and the way they treat their properties and everything, and it's just running everything down, and the council are to blame for that ... because obviously if you have got cheaper housing somewhere, then obviously the people who haven't got the money i.e. a lot of foreign people that have come to this country – they don't have a lot of English pounds for the money that they have, so they are going to move to the cheaper areas. (Focus Group 5)*

Participants across the range of focus groups pointed to housing as lying at the heart of many perceived problems. This in part aligns with Beatty and Fothergill (2003:104) who identify that local unemployment is primarily caused by high in-migration, but the unique nature of housing stock adds “another layer to local joblessness”.

Areas of in-migration were seen to be a direct result of government policy in some cases, but also of new communities congregating together. There was much discussion in focus group 12 in particular around perceptions of large sums of government funds being poorly and inappropriately targeted toward immigrant communities in specific areas, including Dover, Thanet and Sheppey. However, there was also discussion as to whether the government policy actually (and actively) encouraged immigrants to congregate in their own communities, or whether this would happen anyway. The following comments from Focus Group 2 illustrate what many were thinking:

*But unfortunately the government tend to... like Dover, parts of Dover and Folkestone have become renowned now as immigrant areas, so they tend to congregate and group close together, so they have their own community.*

*The government don't necessarily impose areas – I think immigrants stay together.*

*That is what I mean. They start – they put them, and then they tend to attract everybody, so where there was a few, there's a lot now because they tend to want to be together.*

The concentration of deprived communities around lower cost housing stock was seen to engender a range of health issues arising from apathy. Housing was seen to affect physical and mental health (e.g. depression

leading to overweight, stress from overcrowding – Focus Group 12), but also behaviours leading to a decline in health. For example:

*... but if people are going to have lack of pride of their own environment, where they live, then maybe they are going to have a lack of respect for their bodies too, and not bother to eat and drink the right things and that's going to affect their health; maybe they haven't got much money either because they are maybe unemployed or on benefits. (Focus Group 5)*

The issue of very basic democracy and voting rights was also raised. Focus Group 5 concentrated on their perceptions of the nature of the mobile and very fluid bed and breakfast community and questioned whether many residents were actually on the electoral roll, or entirely disenfranchised.

### **A new immigrant community?**

Participants saw the rapidly changing community as part of a dual process of benefit-dependent residents arriving from other areas, including London, but also because of immigrants. This caused some participants to doubt the validity of some of the data provided overall on the maps, suggesting that it might be skewed owing to continued migration and immigration, but nevertheless reporting that areas of economic depression had poor health (Focus Group 12). Participants did not generally or decisively distinguish between immigrants as economic migrants, asylum seekers or refugees in this study, but the issue of immigration (and perceived health relationships) was raised in many of the focus groups (in particular Focus Groups 1, 8, 12):

*Well, I am looking down at the Folkestone area and I used to live down in Dover so I know down there pretty well and I wouldn't have thought that that was a particularly deprived area, although I must admit since we lived there, there have been a lot more asylum seekers and people like that, that affect the health of the area maybe. (Focus Group 1)*

*... it should be remembered that there are a lot of people in areas like Margate and Dover who are on state benefit, who are immigrants... (Focus Group 12).*

Some participants viewed – and blamed the council for allowing – a new population as comprising immigrants as well as ‘English people’, jointly seen as ‘running things

down' in already 'cheaper areas' (for example, Focus Group 5). This was seen to create general apathy, and participants reported a 'clash of cultures'. There were many comments across a range of focus groups suggesting that the high number of immigrants was in part responsible for a negative effect on health and lower life expectancy. Some groups had strong negative perceptions about the effect of immigration and overcrowding on introducing and enabling disease (and 'germs') into their area (in particular, Focus Groups 1, 3, 8, 12), in part suggesting differentials in health care services. For example:

*Well, obviously because they have come from possibly a country where their health service hasn't been as good as ours and they have brought... TB has come back into the country again because ... And so obviously, like these areas, there's going to be more of a health problem because of this – they've have had lack of healthcare in their own country, so their fitness and their standard of health is going to be low, so it will make the area more deprived, and their resources for the health centres and everything... there will be more of a demand with the costs and everything for the health areas – it will be more for those areas. (Focus Group 12).*

A dichotomous view emerged as to how marginal communities were seen and the resources available to them to turn around their fortunes. Some saw deprivation as being so entrenched that it was difficult to see a way forward:

*Because people say "Oh you have got more time on your hands if you don't work, so you have got more time to prepare fresh vegetables, you have got more time to make your own pies, to do this, to do that," but it's actually the motivation that goes with that, and if everything else is wrong in your life, then are you going to have the motivation to actually spend two hours a day cooking? (Focus Group 4)*

While others took more of a 'victim blaming' approach:

*Obviously, the areas which are high in unemployment, so that causes social problems... within the home if people are long-term unemployed or long-term sick; they become stuck in a rut and it's hard to get out so they – some of them more often than not spiral down rather than rise up above things, and it causes ongoing problems... I just know a little bit about Margate and Dover and there are places down*

*there where people have the attitude that education is a waste of time and they don't bother to... take advantage of the education that is available to them. They don't get the parental support – all of which leads to a lower standard of living, and the lower standard of living gives them a lower expectation of life. If you bring in people from another country, as they have done in many of these areas, immigrants, they want perhaps more help to push them to look after themselves better. But there are many people who – you can work as hard as you like – but you won't shift them. That's the way they like it and that's the way they will do it. (Focus Group 12)*

### **Opportunities for community led regeneration**

While it would be easy to assume that the socio-economic problems of seaside towns are so entrenched that it would be difficult to find ways forward, research has suggested that there is in fact a more positive picture. For example, many people move to seaside towns because they choose to do so and many would like to be in paid employment. Indeed, many seaside areas are attractive places to live, providing a reason for immigration, and their economies are unique and evolving (Beatty and Fothergill, 2003).

While coastal areas are attracting those of later working age and the retired, this is also a community that is seen to have positive resources and benefits in economic activity and spending, but also time and energy to invest in community activities. This can help bring opportunities to coastal areas, not least the possibility of an increased demand for improved infrastructure. There is a need for policy makers to take a broader approach to acknowledge the diversity of older people and the need for them to remain active as citizens in voluntary roles (Atterton, 2006).

Recently policy has been increasingly geared toward identifying local need and finding sustainable solutions, with an emphasis on communities increasingly taking a lead in this process to develop capacity. The participants in this study offered commentary on what they perceived as problems of coastal communities, but also drew from their experiences in offering some insights into possible solutions.

Many participants regretted the demise of community (for example, Focus Groups 2, 3, 5, 8, 9) and the following quote is representative of what other groups were thinking:



*Social and community networks – they are very important for health and communication. If you haven't got these networks, what happens to people is that they are in their house, they are ill, which all those people who are ill at the moment have found you can be sitting in your house, alone, and feel totally isolated.*

*And dejected.*

*And also that will impact on your health because you will get depressed and loneliness. So social and community networks are of the utmost importance (Focus Group 2)*

Although some of the following quotes are not specifically on the issue of coastal communities, they provide useful insight into participants' views on helpful capacity-building initiatives in their own communities, which had provided a major boost to confidence, morale and feelings of inclusion. Comments are particularly drawn from the more 'deprived' focus groups.

Generally, respondents favoured local initiatives that could help facilitate change. Such local centres were especially favoured by focus groups carried out in the more deprived areas, particularly when facilities offered were very informal and local to the community with a snowballing effect in involving people:

*It's great, absolutely great – fantastic work they do – absolutely fantastic.*

*I think it's good because I think it's better than the councillors sitting on a bench or anything – a Council officials sitting on their backsides and twiddling their thumbs and waiting for something to come along. Whereas there are people like ourselves who see the problems – we're basically like police officers, if you want to say that, on the front line. You know, we are not nosy neighbours and things like that, but we look out for the community because some of us have been there 'x' number of years. (Focus Group 7)*

Participants particularly commented on the support offered by such community facilities, seen to have a positive effect on mental health (Focus Group 7).

The role of local authorities – and the nature of some of the people employed there – was raised several times (for example Focus Group 1), and some suggested a sense of complacency within councils, failing to invest in declining areas,

*...and it's not until they fall into decay that something gets done really. (Focus Group 5).*

Others suggested that regeneration budgets themselves were at fault in failing to pay for health more wholly, and not as inappropriate separate budgets that seemed endlessly delayed (for example Focus Group 4). Participants suggested that their views were not taken into account by their local authority. For example,

*I don't see why they ask; it depresses you because they ask, and then ignore. (Focus Group 4)*

#### **Taking a proactive view: local authorities and the private rented housing sector**

Focus Groups reported both poor physical housing conditions as well as the behaviour of some residents which they saw as being detrimental to some areas. For example, Focus Group 5 in particular referred to:

*... but there's a lot of apathy in the area and there are a lot of landlords who buy up the houses and basically don't care about the property as such; as long as they have got a tenant in there giving them rent, or the council is paying rent via benefits, they don't keep the properties up to scratch. And the people who are living in those properties – I mean I have got friends who rent property – they do up their property, they decorate it, they look after it, but also I have got neighbours – excuse my language, that don't care a \*\*\*\* ... as long as they have got a roof over their head, they are more nuisance to the rest of us. (Focus Group 5)*

Housing regeneration has now been recognised as a key policy response in starting to address some of the unique issues surrounding coastal areas. New powers in the Housing Act, 2004 now provide for mandatory licencing of some houses in multiple occupation (which includes bed and breakfast accommodation). These powers seek to improve physical conditions and management standards for occupants and the wider environment to help create more sustainable communities and better quality of life. Alongside discretionary selective licencing of private sector landlords, the government seeks to address anti social behaviour and poor quality environments through better management (ODPM, 2006). These powers run alongside other national requirements to meet the needs of asylum seekers and for local strategies to tackle homelessness as well as more emphasis on local strategies and decision making generally.

Local policy makers need to be able to balance statutory requirements in addressing regeneration and housing (in property management and health) and also to support community development, particularly within the most marginal communities. However, it can be particularly challenging for local services and agencies to engender community involvement in local regeneration with such a transient, marginal and vulnerable community disproportionately reside in poor quality HMOs and care homes (ODPM, 2006). While there are now more powers under housing legislation, there may be a need for further provisions to manage problems associated with especially large numbers of coastal HMOs (ODPM, 2006).

At the time of this research, several documents were being published around coastal issues and this may have had some impact on interest shown by the focus groups on coastal areas. Most notably, the (then) ODPM (2006) published *Housing, Planning, Local Government and the Regions Committee: Coastal Towns Session 2005-06, Written Evidence*, and the Communities and Local Government Select Committee (2007) published *Communities and Local Government Committee Coastal Towns: Second report of Session 2006/7*. More recently, English Heritage (2007) published its report *An Asset and a Challenge: Heritage and Regeneration in Coastal Towns in England*, which presented some Kent-based case studies on successful regeneration initiatives in the region, although the remit of this report was about identifying local heritage assets and seeking public private funding initiatives to regenerate towns, rather than health *per se*.

Policy makers are faced with addressing a variety of complex issues in regenerating coastal areas, but housing emerges as a key issue both in terms of need (allocation) and regeneration (including heritage management). There are difficult public sector decisions around balancing historic preservation and contemporary need. There have been some Kent Coast examples of successful regeneration initiatives reported by English Heritage and Urban Practitioners (2007). For example, Whitsable's regeneration had focused around its historical fishing industry; Margate's socio-economic strategies include grants to address historical fabric and conservation, housing and property rehabilitation, entertainment and transport links; Folkestone has suffered from its proximity to the Channel Tunnel, but has brought vacant properties back into use and diversified attractions for visitors; and Hastings had sought to maximise its historic architecture and residential neighbourhoods and diversified the local economy.

Many local authorities have been active in trying to find solutions to their local housing markets, including responding to the high numbers of empty properties (Allan, 2007) and low value housing in east Kent. Kent was reported as having 9,000 empty homes, most in Thanet, Dover, Shepway and Swale (Spear, 2008). Kent launched its 'No Use Empty' campaign in 2005 as a joint working initiative between planning, housing, building control and environmental health departments, supported by partnership funding. The campaign aims to bring some 7,000 properties back in to use, assisted by joint working initiatives such as Local Area Agreements and Public Services Agreements (ODPM, 2006). As also identified across many of the focus groups, the campaign found that landlords are not compliant with legislation and joint working has been found to be the best way forward in regeneration (Spear, 2008).

However, the local authority roles in planning, building control and housing enforcement standards can sometimes be contradictory. With any regeneration strategy, gentrification can further alienate already marginalised lower income households. However, communities themselves are able to offer insight into what they have themselves found helpful in their areas.

### Conclusions

The English coast was traditionally viewed as health giving, but has struggled to find a new role with the decline of tourism and loss of other local economies. Loss of local economies has led to a downward spiral in some areas, creating a new socially and economically excluded vulnerable and transient community residing in poor private sector housing accommodation, living alongside the original community, presenting major new challenges for policy makers. The government has also acknowledged that Kent has local and specific needs arising from the fact that the ex-resorts tend to lack the focus of other coastal areas, which benefit from their other resources. Many of the focus group comments align closely with many of the observations and issues identified in recent government research. However, not all Kent coastal areas are equally affected, and Victorian resorts are less affected.

These findings add to the literature of lay understanding of inequalities in health, as well as to the relatively limited literature around housing, health and communities on the Kent coast. This work helps to demonstrate the importance of meaningful dialogue between statutory and non-statutory services and the

relationship to the public. It is important to build on local initiatives where possible and to develop sensitive local services. Also, there is a need for these observations to be set in the context of recent thinking on the need to develop new strategies for involving communities to help encourage sustainable change.

Strategies need to involve communities affected, although it is recognised that it can be extremely challenging to involve such a transient vulnerable community in new ways of tackling socio-economic disadvantage and poor housing conditions. However, government requirements and local partnerships have provided an impetus to seek to involve those affected and there are many new legislative provisions to tackle the many complex and multifaceted housing, social, economic and environmental conditions faced by those suffering some of the most acute health inequalities in an otherwise relatively affluent area.

## Acknowledgements

EU InterReg IIIA for funding, COSPH project colleagues and supporters, and the PCTs and Health Authorities who commissioned the surveys in England (see also [www.cosph.com](http://www.cosph.com))

We acknowledge the contribution to the research of: Professor Annmarie Ruston, Julie Clayton, Alex Knight, Kirsty Carmichael and Vicky Bradshaw, all previously of the University of Greenwich.

## References

**Allen K** (2007). Beached Progress. *Inside Housing*, 9 March 2007.

**Atterton J** (2006). Ageing and Coastal Communities: Final report for the Coastal Action Zone Partnership. Centre for Rural Economy Research Report, September 2006, Centre for Rural Economy, University of Newcastle upon Tyne.

**Beatty C and Fothergill S** (2003). The Seaside Economy: The final report of the seaside towns research project, June 2003. Centre for Regional Economic and Social Research, Sheffield Hallam University.

**Blaxter M** (1997). Whose fault is it? People's own conceptions of reasons for health inequalities. *Social Science and Medicine*, 44 (06), 747-756.

**Communities and Local Government Select Committee (CLG)** (2007). Communities and Local Government Committee Coastal Towns: Second report of Session 2006/7, Online. Available online at: [www.publications.parliament.uk/pa/cm200607/cmselect/cmcomloc/351/35102.htm](http://www.publications.parliament.uk/pa/cm200607/cmselect/cmcomloc/351/35102.htm) [accessed 05/06/09].

**Curtis S** (2004). Health and Inequality; Geographical Perspectives, London: Sage.

**Davidson R, Mitchell R and Hunt K** (2007). Location, location, location: The role of experience of disadvantage in lay perceptions of area inequalities in health. *Health and Place*, 14 (02), pp. 167-181.

**Department for Work and Pensions (DWP)** (2004). Opportunity for all: Sixth annual report 2004, chapter 2: deprived areas; who lives in deprived areas? Available online at: [www.dwp.gov.uk/ofa/reports/2004/chapter2-6.asp](http://www.dwp.gov.uk/ofa/reports/2004/chapter2-6.asp) [accessed 05/06/09].

**Edelman C L and Mandelson C L** (2006). Health Promotion Throughout the Lifespan, Missouri: Elsevier Mosby.

**English Heritage and Urban Practitioners** (2007). An asset and a challenge: Heritage and regeneration in coastal towns in England. Final Report, October 2007. English Heritage.

**Gatrell A C** (2001). Geographies of Health: an introduction. Blackwell Publishing.

**Gatrell A C and Elliot S J** (2009). Geographies of Health: an introduction (2nd edition). Wiley Blackwell

**Meerabeau E and Stewart J** (2007). Franco-British Interreg IIIA European Programme Comparison of Sante/Public Health Project. Health and Health Behaviour in South East England and Northern France: An investigation of the views and perceptions of residents in Kent, Medway and Nord Pas de Calais of health determinants, health status and opportunities for health improvement: a qualitative study. Document reporting on the Qualitative Workstream Study carried out in South East England by the University of Greenwich. Unpublished.

**Office of the Deputy Prime Minister (ODPM)** (2006). Housing, Planning, Local Government and the Regions Committee: Coastal Towns Session 2005-06. Written Evidence, London: House of Commons Online. Available



online at: [www.publications.parliament.uk/pa/cm200506/cmselect/cmodpm/1023/1023ii.pdf](http://www.publications.parliament.uk/pa/cm200506/cmselect/cmodpm/1023/1023ii.pdf) [accessed 05/06/09]

**Popay J, Bennett S, Thomas C, Williams G, Gatrell A and Bostock L** (2003). Beyond 'beer, fags, eggs and chips'? Exploring lay understandings of social inequalities in health. *Sociology of Health and Illness*, 25 (01), 1-13

**Spear S** (2008) End of story. *Environmental Health Practitioner*, 4 July 2008. Online. Available online at: [www.cieh.org/ehp/ehp3.aspx?id=12982](http://www.cieh.org/ehp/ehp3.aspx?id=12982) [accessed 05/06/09]

**Ward P** (2008). Beside the seaside. *Inside Housing*, 29 February 2008, pp.30-33.

**Weaver M** (2007). Cities 'dumping' problem families in seaside towns. *The Guardian*, Wednesday March 7, 2007.



# Oxidative stress and antioxidants status of occupational pesticides exposed sprayers of grape gardens of Western Maharashtra (India)

Dr Jyotsna A Patil<sup>1</sup> MSc PhD (Medical), Dr Arun J Patil<sup>1</sup> MSc PhD, Dr Ajit V Sontakke<sup>1</sup> MD, Dr Sanjay P Govindwar<sup>2</sup> MSc PhD

<sup>1</sup> Department of Biochemistry, Krishna Institute of Medical Sciences University, Karad, Maharashtra, Pin-415110

<sup>2</sup> Shivaji University Kolhapur, Maharashtra, Pin-416004 India.

**Correspondence:** Dr Arun J. Patil, Associate Professor, Department of Biochemistry, Krishna Institute of Medical Sciences University, Karad, District Satara, Maharashtra (India) Pin-415110. Telephone: (R) 91 2164 242321, 91 2164 242312. Email: ajyotsna1@yahoo.co.in

## Abstract

This study was undertaken to assess oxidative stress and antioxidant status of sprayers of grape gardens of Western Maharashtra (India). Sixty sprayers of grape gardens (study group) and 30 pesticides-unexposed normal healthy subjects (control group) were taken (age 20 to 45 years) from the Western Maharashtra (India). Demographic, occupational, dietary and clinical data were collected by questionnaire, interview and observation and venous blood samples were collected from both groups.

The serum lipid peroxide level of sprayers of grape gardens (N = 60) was found to be in the range of 2.27 to 6.17 nmol/ml of Mean  $\pm$  SD,  $3.30 \pm 0.58$  nmol/ml of MDA, whereas that of the pesticides unexposed control group (N = 30) was in the range of 1.68 to 4.50 nmol/ml of Malondialdehyde [MDA] (Mean  $\pm$  SD,  $2.39 \pm 0.57$  nmol/ml of MDA). This means that the serum lipid peroxide levels of sprayers of grape gardens were significantly increased by 38.07% ( $P < 0.001$ ) as compared to control group. The antioxidant status parameters such as erythrocyte superoxide dismutase, catalase, and plasma ceruloplasmin were significantly decreased by 24.02% ( $P < 0.001$ ), 39.72% ( $P < 0.001$ ), 10.98% ( $P < 0.05$ ) respectively in sprayers of grape gardens as compared to control group. Glutathione S-transferase activity was significantly increased by 80.55% ( $P < 0.01$ ) in sprayers of grape gardens as compared to control group. Serum zinc and copper levels were significantly decreased by 9.06% ( $P < 0.05$ ), 5.37% ( $P < 0.01$ ) respectively in sprayers of grape gardens as compared to control group.

Therefore, this study suggests that exposure to the various pesticides causes an imbalance of prooxidant/antioxidant status in sprayers of grape gardens from Western Maharashtra (India).

**Key words:** Catalase (CAT); ceruloplasmin (CP); Cu; environmental health; GST; lipid peroxide (LP); occupational health; pesticides, sprayers of grape gardens; superoxide dismutase (SOD); Zn.

## Introduction

The land used for cash crop like grapes is on the rise particularly in Maharashtra state (India). More pesticides are being used for controlling the various pests in grape gardens and to increase the yield. The environmental pollution and poisoning owing to the widespread use of

pesticides during grape cultivation may be disturbing the socio economical status of uneducated farm workers in rural areas (Dave, 1998). Pesticides or their residues are ubiquitous contaminants of our environment and found in air, soil, water, and in human and animal tissue samples from all over the world.

Mainly organochlorines, organophosphorous, carbamates, pyrethroids compounds, and various inorganic compounds are used for controlling the various pests. The common organophosphorous and carbamates pesticides used in grape gardens are Basathrin 25 EC (Cypermethrin 25% EC), Nuvan (Dichloroovas 76% EC), Nuvacron (Monocrotophos 36% EC), Dimethoate 30% EC (CHAMP 30 EC), Phosphamidon 85% SL (Dimecron), Kilex Endosulfan 35% EC, Carbaryl, Cypermethrin 25% EC (JAWAA), Monocrotophos 36% SL, Methomyl

Pesticides uptake occurs through the skin, eyes, by inhalation, or by ingestion. The fat-soluble pesticides, and to some extent, the water-soluble pesticides are absorbed through intact skin. Sores and abrasions may facilitate uptake through the skin. The vapours of pesticides or aerosol droplets smaller than 5 $\mu$ m in diameters are absorbed effectively through the lungs. Larger inhaled particles or droplets may be swallowed after being cleared from the airways. Ingestion can occur from the consumption of contaminated food or from using contaminated utensils. Contaminated hands may also lead to an intake of pesticides, for example, while pan chewing, tobacco eating, bidi smoking and while spraying, mixing, or handling the pesticides (WHO / UNEP (1990). The dermal exposure is the most important route of uptake of pesticides for exposed workers.

Pesticides are metabolised by oxidation and hydrolysis by esterases and reaction with glutathione, demethylation and glucuronidation may occur. The glutathione transferase reactions produce products that are, in most cases, of low toxicity. Pesticides are mostly eliminated in the urine with lesser amounts in the faeces and expired air.

Headache, fatigue, dizziness, loss of appetite with nausea, abdominal cramps and diarrhoea, blurred vision with watering of eyes, excessive sweating and salivation, bradycardia and twitching of muscles are some of the common signs and symptoms of mild exposures to organophosphate and carbamate insecticides.

Pesticides inhibit a number of enzymes in humans. They affect several physiological systems and processes in the body – the central nervous system (CNS), reproductive,

immune, endocrine, cardiovascular and respiratory systems. Not only that, they have an effect on various metabolisms, fluid and electrolyte balance and have carcinogenic potential, particularly in the liver (WHO 1992, 1993).

The adverse effects from exposure to pesticides depends on the dose, the route of exposure, how easily the pesticide is absorbed, and the types of the pesticides, their metabolites, their accumulation and persistence in the body. The toxic effect also depends on the health status of the individual – malnutrition and dehydration are likely to increase sensitivity to pesticides.

The increased formation of reactive oxygen and nitrogen species result in an increase in lipid peroxidation in several tissues mainly the brain, skeletal muscle and red blood cells (RBC) and depleted antioxidant status were reported in several studies of various pesticide-exposed populations (Dave 1998, WHO/UNEP 1990). The pesticides may irritate lung macrophages, encouraging them to generate the superoxide radicals and deplete antioxidants status. Therefore, in this study we have planned to see the oxidative stress and antioxidant status of sprayers of grape gardens. To achieve our aim, we have measured serum lipid peroxide, erythrocytes superoxide dismutase, catalase, plasma ceruloplasmin, serum glutathione S-transferase. We also measured serum zinc, and copper levels.

## Methods

This study comprises 60 subjects with occupational pesticides exposure i.e. sprayers of grape gardens (study group) and 30 normal healthy subjects, who were not exposed to pesticides (control group). All the study group subjects were in the age range of 20 to 45 years and were taken from Tasgaon Taluka, District Sangli (Western Maharashtra) India. The age-matched normal healthy control subjects working in fields but not performing spraying activities and did not have any kind of pesticide exposure were taken from the same area. Prior to data and biological specimen collection, sprayers of grape gardens were informed on the study objectives and health hazards of pesticides exposure, precautions to reduce pesticides exposure and written consent was obtained from all sprayers and control subjects. Demographic, occupational and clinical data were collected using questionnaires and interviews. All the subjects of the study and control groups belong agricultural families with similar socio-economic status. None of the subjects had a past history of major illness.

Dietary intake and food habits of all subjects were normal, which was confirmed periodically by checking their tiffins during their lunch. It was also verified that they had their routine breakfast and dinner. Out of the 60 study group subjects 40% had completed their primary school, 50% had passed high school and 10% attended higher education institutions. Control subjects were selected to provide a similar educational distribution. Subjects who were found to be on drugs for minor illnesses were excluded. Non-smokers, non-alcoholic healthy males, who were occupationally exposed to various pesticides ie sprayers of grape gardens for more than five to 15 years duration of exposure were selected. The study group subjects were engaged continuously four to five hours daily for spraying pesticides in the months of October to January. Blood samples of these subjects were collected in the month of January, because sprayers of grape gardens are most exposed to pesticides at this time of year. The entire experimental protocol was approved by the institutional ethical committee, and utmost care was taken during the experimental procedure according to the Helsinki declaration of 1964. Blood samples were collected by puncturing the antecubital vein into evacuated tubes containing heparin solution as anti-coagulant.

Lipid peroxidation was measured spectrophotometrically by method of Satoh (1978). Serum proteins were precipitated by trichloroacetic acid (TCA) and the mixture was heated for 30 min with thiobarbituric acid in 2M sodium sulfate, in a boiling water bath. The resulting chromogen was extracted with n-butyl alcohol and the absorbance of the organic phase was determined at a wavelength of 530nm. The values were expressed in terms of malondialdehyde (MDA) nmol mL<sup>-1</sup> using 1, 1, 3, 3, tetraethoxy propane as the standard.

The activity of erythrocyte superoxide dismutase (SOD) was measured by the method Marklund and Marklund (1988). Superoxide anion is involved in the auto-oxidation of pyrogallol at alkaline pH 8.5. The superoxide dismutase inhibits the autooxidation of pyrogallol, which can be determined as an increase in absorbance per two minutes at 420 nm. The SOD activity was measured as units mL<sup>-1</sup> hemolysate. One unit of superoxide dismutase is defined as the amount of enzyme required to cause 50% inhibition of pyrogallol auto-oxidation.

Erythrocyte catalase was measured by the method of Aebi (1983). Heparinized blood was centrifuged and plasma was removed, and the erythrocytes were washed

# Oxidative stress and antioxidants status of occupational pesticides exposed sprayers of grape gardens of Western Maharashtra (India)

2-3 times with 0.9% NaCl and then lysed in 10 volumes of cold deionized water. The whole mixture was centrifuged for 10 min at 3,000 x g. The cell debris was removed and the clear hemolysate was diluted 500 times with phosphate buffer (60 mM) pH 7.4. Catalase decomposes H<sub>2</sub>O<sub>2</sub> to form water and molecular oxygen. In the UV range, H<sub>2</sub>O<sub>2</sub> show a continual increase in the absorption with decreasing wavelength. At 240 nm, H<sub>2</sub>O<sub>2</sub> absorbs maximum light. When H<sub>2</sub>O<sub>2</sub> is decomposed by catalase, then the absorbance decreases. The decreased absorbance was measured at 240nm for every 15 seconds interval up to 1 min and the difference in absorbance ( $\Delta A$  at 240 nm) per unit time is a measure of the catalase activity. The unit of catalase activity was expressed as mM of H<sub>2</sub>O<sub>2</sub> decomposed /mg Hb min<sup>-1</sup>.

Plasma ceruloplasmin was measured by the method of Herbert and Ravin (1961). Ceruloplasmin oxidises P-phenylenediamine in the presence of oxygen to form a purple-colored oxidised product. The ceruloplasmin

concentration was determined from the rate of oxidation of P-phenylenediamine at 37°C at pH 6.0, which has an absorption peak at 530 nm.

Serum Glutathione S-Transferase (GST) was measured by using the Habig *et al.* (1974) method. The GST activity was determined by measuring the conjugation of 1-chloro-2, 4-dinitrobenzene (CDNB) with reduced glutathione. The conjugation was accompanied by an increase in absorbance at 340nm. The rate of increase is directly proportional to the GST activity in the sample. The serum zinc and copper were measured using a Perkins Elmer model 303 graphite furnace atomic absorption spectrophotometer, which was connected to an Hitachi 165 recorder; values were shown in  $\mu\text{g dl}^{-1}$  (Mert and Henkin, 1971).

## Results

See Table 1.0 and Figure 1.0 below.

Sr. No.	Parameters	Control Group N = 30	Study Group N = 60
<b>A</b>	Lipid peroxide (LP) [nmol/ml of MDA]	2.39 ± 0.57 (1.68 – 4.50)	3.30 ± 0.58*** (2.27 – 6.17)
<b>B</b>	<b>Antioxidants Status</b>		
1	RBC- Superoxide dismutase (SOD) [Unit/ml of hemolysate]	13.11 ± 2.18 (7.89 - 16.93)	9.96 ± 1.58*** (5.79 – 16.23)
2	RBC – Catalase (CAT) (mM H <sub>2</sub> O <sub>2</sub> decom/mg Hb/min)	14.02 ± 2.96 (8.25 – 20.23)	8.45 ± 3.81*** (4.23 – 21.13)
3	Plasma Ceruloplasmin (CP) [mg/dl]	77.57 ± 13.82 (28.36 – 98.60)	69.05 ± 16.81* (27.91 – 93.54)
4	Glutathione S-transferase (GST) <sup>a</sup>	0.054 ± 0.032 (0.019 – 0.158)	0.099 ± 0.058** (0.020 – 0.271)
<b>C</b>	<b>Trace elements</b>		
1	Serum Zinc (Zn) [ $\mu\text{g/dl}$ ]	89.80 ± 9.01 (74 – 117)	81.66 ± 13.73* (54 – 115)
2	Serum Copper (Cu) [ $\mu\text{g/dl}$ ]	87.46 ± 10.81 (60 – 110)	82.76 ± 16.51** (51 – 130)

<sup>a</sup>  $\mu\text{mol}$  of conjugate formed/min/mg of protein.

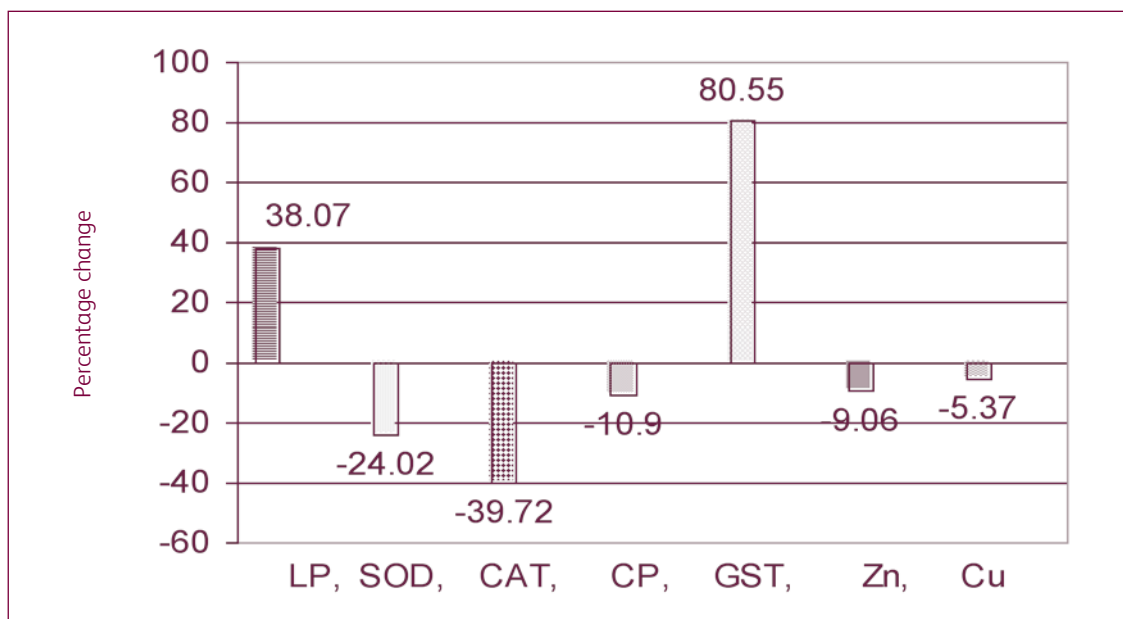
Figures indicate Mean  $\pm$  SD values and those in parenthesis are range of values.

\* P < 0.05, \*\* P < 0.01, \*\*\* P < 0.001.

**Table 1.0**

Mean values of lipid peroxide, antioxidants, enzymes and trace elements in sprayers of grape gardens and control groups.

**Figure 1.0**  
Percentage change of mean values of lipid peroxide, antioxidants enzymes and trace elements of sprayers of grape gardens with respect to control group.



Lipid Peroxide (LP), RBC – Superoxide dismutase (SOD), RBC – Catalase (CAT), Plasma Ceruloplasmin (CP), Glutathione S-transferase (GST), Serum Zinc (Zn), Serum Copper (Cu).

## Discussion

In this study, we have estimated serum lipid peroxide from 60 sprayers of grape gardens and found statistically significantly increased  $P < 0.001$  (38.07%) as compared to the control group. Increased lipid peroxide level in this study might be caused by various pesticides used in grape gardens. The commonly used pesticides are basathrin, nuvan, nuvacron, dimethoat, phosphamidon, endosulfan, carbaryl, cypermethrin, monocrotophos, and methomyl in Western Maharashtra (India). Most of the sprayers of grape gardens had major complaints of lacrimation, nausea, salivation, snuffling, headache, breathlessness, itching and vomiting.

The role of oxygen free radicals (OFR) has been well established in many chronic disorders, the significance of the implication of OFR in an acute condition like organophosphate (OP) poisoning in sprayers of grape gardens has not been investigated so far. Reactive oxygen species (ROS) are implicated as important pathological mediators in many disorders. Lipid peroxidation constitutes a complex chain reaction of free radicals, which leads to a degradation of polyunsaturated fatty acid in cell membrane (Halliwell and Gutteridge 1986). Present study reveals that the various pesticides increase

lipid peroxidation by increasing MDA concentration in plasma of sprayers of grape gardens. Increased plasma MDA concentration in this study definitely accompanied by increased ROS formation. Consequently, enhanced lipid peroxidation, and alteration of antioxidant defence system occurred. Increased lipid peroxide level owing to exposure of OP and carbamate pesticides were reported in several studies (Daves 1998; WHO, 1992, 1993; Patil *et al.*, 2003; Pawar *et al.*, 1978; Prakasam *et al.*, 2001). Moreover, OP, carbamate and endrin increased lipid peroxidation in both liver and kidneys in experimental animals (Pawar *et al.*, 1978). Endosulfan administration also results in a change in membrane permeability of erythrocytes and blood glutathione level (Khanna, *et al.*, 1982).

Pesticides have been shown to initiate peroxidation of lipids in biological membranes (Koryagin *et al.*, 2002; John *et al.*, 2001). In erythrocytes, organophosphate has shown to produce morphological changes that are associated with increased lipid peroxidation (John *et al.*, 2001; Thapar *et al.*, 2002; Altuntas *et al.*, 2002). The effect of lipid peroxidation on membrane lipids, membrane receptors and membrane-bound enzymes can alter the function, structure and fluidity of membranes and may result in altered ion flux (Halliwell *et al.*, 1993). Generation of oxidative stress and

## Oxidative stress and antioxidants status of occupational pesticides exposed sprayers of grape gardens of Western Maharashtra (India)

consequent lipid peroxidation by pesticides reported in rat and human brain (Verma, and Srivastava *et al.*, 2001; Ranjbar *et al.*, 2002). Increased lipid peroxide levels in sprayers of grape gardens are supported by earlier pesticides exposure studies.

Erythrocytes SOD activity was significantly decreased  $P < 0.001$ , (24%) in the study group as compared to the control group. Earlier studies in animals have also shown that pesticides such as paraquat, 2,4-D, and endosulfan can inhibit the activity of erythrocyte-SOD and induce oxidative stress in hepatocytes as well as in the central nervous system (Bebe *et al.*, 2003; Yamano *et al.*, 1992; Julka *et al.*, 1992). Moreover, current research indicates that many widely used agricultural chemicals induce oxidative damage in various systems of the body such as in dopaminergic cells of the brain by modulating the antioxidant defence system (Barlow *et al.*, 2005).

The pesticides may irritate lung macrophages, encouraging them to generate the superoxide radical. Pesticides may be more active to an oxygen free radical that re-oxidises to make superoxide, the pesticide may itself be a free radical, or they may deplete antioxidant defences. The overall effect is the production of more free radicals. The superoxide dismutase, glutathione peroxidases and glutathione reductase decreased, owing to consumption of enzymes to neutralise free radicals generated by pesticides (Amer *et al.*, 2002).

In the present study, RBC-SOD activity was slightly, though significantly, inhibited in the sprayers of grape gardens. However, it is unclear whether the pesticides or their reactive metabolites suppressed SOD activity. Decreased SOD activity might be caused by the decreased serum zinc and copper levels, since SOD is a Zn-Cu containing enzyme. In this study, we found significantly decreased serum zinc  $P < 0.05$ , (9%) and copper  $P < 0.01$ , (5%) in sprayers of grape gardens as compared to the control group. Since SOD is known to be an enzyme induced by its superoxide radical substrate, decreased activities indicates more generation of superoxide radicals in sprayers of grape gardens. Initially, SOD activity may be increased, but owing to prolonged exposure to pesticides, decreased SOD activity was observed in this study.

Erythrocytes catalase activity was significantly decreased  $P < 0.001$  (39.72%) in sprayers of grape gardens as compared to control group. Catalase activity in erythrocytes may be explained by their influence on hydrogen peroxide as substrate, which is formed in the

process of dismutation of superoxide anion radicals (Shaikh *et al.*, 1999). As catalase is a heme containing enzyme and the fact that pesticides inhibit  $\delta$ -ALAD activities (Panemangalore and Byers, 1995), which is involved in heme synthesis, it is obvious that pesticides are responsible for the decrease in catalase activity in RBC. Therefore, decreased erythrocytes catalase might be caused by more generation of  $H_2O_2$  or decreased heme synthesis by the pesticides in this study.

Plasma ceruloplasmin levels were slightly decreased  $P < 0.05$ , (10.98%) in sprayers of grape gardens as compared to the controls. Ceruloplasmin is a multi-functional enzyme which performs many physiological functions. Ceruloplasmin plays an important regulatory role in iron metabolism whereby it assists the release of iron from cells prior to its uptake by transferrin (Osaki *et al.*, 1971). Ceruloplasmin converts  $Fe^{2+} \rightarrow Fe^{3+} + e^-$  and removes  $Fe^{2+}$  from the blood that may otherwise become involved in the generation of harmful reactive oxygen species. Further, the reduction of  $Fe^{3+}$  to  $Fe^{2+}$  by  $O_2^{\bullet-}$  would provide a mechanism for the scavenging of  $O_2^{\bullet-}$ . The physiological significance of such a mechanism would, of course, be determined by the availability of iron and the relative activities of SOD and ceruloplasmin. SOD is involved first for scavenging the  $O_2^{\bullet-}$ , and then ceruloplasmin might be involved. Therefore, decreased plasma ceruloplasmin in sprayers of grape gardens might be caused by more generation  $O_2^{\bullet-}$  by various pesticides.

Serum glutathione-S-transferase activity was significantly increased  $P < 0.01$  (80.5%) in sprayers of grape gardens as compared to the control group. Glutathione-S-transferases are a major family of detoxifying enzymes that catalyze the conjugation of GSH with electrophilic centres of lipophilic substrates, thereby increasing its solubility and aiding their excretion from the body (Vontas *et al.*, 2001). Increased GST in this study indicates that the OP and carbamate pesticides are mainly metabolised in the liver and excreted as a conjugate of GSH by the reaction catalysed by GST. A pronounced increase (131%) in the activity of GST was observed in animals chronically exposed to carbofuran (Kaur *et al.*, 2006). Glutathione is a ubiquitous tripeptide that plays a significant role in oxidation-reduction reactions, amino acid transport, detoxification of electrophiles and metals, metabolites of xenobiotics and many carcinogens. Glutathione (GSH) is an endogenous thiol antioxidant that has a multifaceted role in xenobiotic metabolism and is a first line of defence against oxidant-mediated cell injury (Sies, 1999). Studies in animal models suggest that

many synthetic organophosphates and organochlorines such as endosulfan and chlorpyrifos modify the concentrations of GSH (Bebe *et al.*, 2003). The levels of GSH showed a drastic reduction (76%) after acute carbofuran exposure (Cereser *et al.*, 2001). Reduced glutathione is one of the most potent biological molecules that affects the scavenging function in the system. Glutathione together with glutathione dependent systems, glutathione peroxidase (GSH-Px), glutathione-S-transferase, catalase, and superoxide dismutase efficiently scavenge toxic free radicals (Reddy *et al.*, 1984).

## Conclusion

This study suggests that pesticides such as basathrin, nuvan, nuvacron, dimethoat, phosphamidon, endosulfan, carbaryl, cypermethrin, monocrotophos, and methomyl cause an imbalance of pro-oxidant/antioxidant status in sprayers of grape gardens from Western Maharashtra (India). This is associated with increased lipid peroxidation with decreased erythrocyte SOD, catalase, plasma ceruloplasmin, zinc, copper and increased glutathione s-transferase activities.

The potential risk of pesticides toxicity will persist unless safety measures are taken by the grape gardens owners. The sprayers of grape gardens should use proper protective devices while spraying the pesticides on grape gardens to reduce the pesticides exposure, and regular monitoring is essential to avoid further ill effects through pesticides exposure.

## Acknowledgements

We express our deep gratitude to all sprayers of grape gardens and control group subjects who volunteered for this project. We are thankful to grape gardens owners for extending their co-operation.

## References

**Aebi H** (1983). Catalase methods in enzymatic analysis (ed) Bergmeyer HU Vol 3, Academic Press, New York. 276-286.

**Altuntas I, Delibas N and Sutcu R** (2002). The effects of organophosphate insecticide methidathion on lipid peroxidation and anti-oxidant enzymes in rat erythrocytes: Role of vitamin E and C. *Human Exp. Toxicol.* 21, 681-685.

**Amer M, Metwalli M and El-Magd Y** (2002). Skin disease and enzymatic antioxidants activity among workers exposed to pesticides. *Eastern Mediterranean Health Journal.* 8, 2 & 3.

**Barlow B K, Lee D W, Cory-Slechta D A and Opanshuk L** (2005). Modulation of antioxidant defence system by the environmental pesticide maneb in dopaminergic cells. *Neurotoxicol.* 26, 63-75.

**Bebe F N and Panemangalore M** (2003). Exposure to low doses of endosulfan and chlorpyrifos modifies endogenous antioxidants in tissues of rats. *J.Env. Sci. Health.* 38, 349-363.

**Cereser C, Boget S, Parvaz P and Revol A** (2001). Thiram induced cytotoxicity is accompanied by a rapid and drastic oxidation of reduced glutathione with consecutive lipid peroxidation and cell death. *Toxicology.* 163, 62-153.

**Dave S K** (1998). Occupational health services for agriculture workers. *Indian J. Occup. Environ. Med.* 2, 96-111.

**Habig W, Pabst M and Jakoby W** (1974). Glutathione S-Transferase. The first enzymatic steps in mercapturic acid formation. *J. Biol. Chem.* 249, 7130-7139.

**Halliwell B and Chirico S** (1993). Lipid peroxidation: its mechanism, measurement and significance. *Am. J. Clin. Nutr.* 57, 715-725.

**Halliwell B and Gutteridge J M C** (1986). Oxygen free radicals and iron in relation to biology and medicine: some problems and concepts. *Arch. Biochem. Biophys.* 246, 501-514.

**Helsinki Declaration** (1964). Amended by World Medical Assembly, Venice, Italy, 1983. *Br Med J* 1996; 313 (70):1448-1449.

**Herbert A, Ravin J** (1961). An improved colorimetric Enzymatic Assay of Ceruloplasmin. *Lab. and Clin. Med.* 161.

**John S, Kale M, Rathore N and Bhatnagar D** (2001). Protective effect of vitamin E in dimethoate and malathion induced oxidative stress in rat erythrocytes. *J. Nutr. Biochem.* 12, 500-504.



## Oxidative stress and antioxidants status of occupational pesticides exposed sprayers of grape gardens of Western Maharashtra (India)

- Julka D, Pal R and Gill K D** (1992). Neurotoxicity of dichlorvos: Effect on antioxidant defence system in the rat central nervous system. *Exp. Mol. Pathol.* 56, 44-52.
- Satoh K** (1978). Serum lipid peroxide in cerebrovascular disorders determined by a new colorimetric method. *Clinica. Chimica. Acta.* 90, 37-43.
- Kaur M and Sandhir R** (2006). Comparative effects of acute and chronic carbofuran exposure on oxidative stress and drug metabolising enzymes in liver. *Drug and Chemical Toxicology.* 29, 415-421.
- Khanna R N, Anand M Misra and Krishnamurti C R** (1982). Proceedings of Indo-US workshop on biodegradable pesticides. Department of Environment, Govt. of India, New Delhi) 165.
- Koryagin A S, Krylova E V and Lukyanova L D** (2002). Effect of ubiquinone-10 on the blood system in rats exposed to radiation. *Bull. Exp. Biol. and Med.* 133, 562-564.
- Marklund S, Marklund G, modified by Nandi** (1988). Assay of SOD activity in tissue. *J. Biochem.* 13, 305-315.
- Mert S and Henkin R** (1971). Simultaneous direct estimation by AAS of copper and zinc in serum, urine and CSF. *Clin. Chem.* 17, 369- 379.
- Osaki S, Johnson D A and Frieden E** (1971). The mobilisation of iron from perfused mammalian liver by a serum copper enzyme, Ferroxidase I. *J. Biol. Chem.* 246, 3018-3026.
- Panemangalore M and Byers M E** (1995). Monitoring exposure and biomarkers in limited resource farmers to AG-chemicals. FEDRIP database. National Technical Information Service (NTIS).
- Patil J, Patil A J and Govindwar S P** (2003). Biochemical effects of various pesticides on sprayers of grape gardens. *Indian J. Clin. Biochem.* 18, 16-22.
- Pawar S S and Kachole M S** (1978). Hepatic and renal microsomal electron transport reactions in endrin treated female guinea pig. *Bull. Environ. Contam. Toxicol.* 20, 199-205.
- Prakasam A and Sethupathy S** (2001). Vitamin E supplementation on biochemical changes observed in agricultural workers exposed to different classes of pesticides. *Indian J. Clin. Biochem.* 16, 185-189.
- Ranjbar A, Pasalar P and Abdollahi M** (2002). Induction of oxidative stress and acetylcholinesterase inhibition in organophosphate pesticide manufacturing workers. *Hum. Expt. Toxicol.* 21, 179-182.
- Shaikh Z A, Vu T T and Zaman K** (1999). Oxidative stress as a mechanism of chronic cadmium induced hepatotoxicity and renal toxicity and protection by antioxidants. *Toxicol. Appl. Pharmacol.* 15, 256-263.
- Sies H** (1999). Glutathione and its role in cellular functions. *Free Radic. Biol. Med.* 27, 916-921.
- Thapar A, Sandhir R and Kiran R** (2002). Acephate induced oxidative damage in erythrocytes. *Indian J. Exp. Biol.* 40, 963-966.
- Vontas J G, Small G J and Hemingway J** (2001). Glutathione S- transferases as antioxidant defence agents confer pyrethroid resistance in *Nilaparvata lugens*. *Biochem. J.* 357, 65-72.
- WHO** (1992). Environmental health criteria, No.130, Endrin. Geneva.
- WHO** (1993). Environmental health criteria, No.145, Methyl Parathion. Geneva.
- WHO /UNEP** (1990). Public health impact of pesticides used in agriculture, Geneva.
- Yamano T and Morita S** (1992). Effects of pesticides on isolated rat hepatocytes, mitochondria and microsomes. *Arch. Environ. Contam. Toxicol.* 28, 1-7.



# Distribution pattern of a dengue fever outbreak using GIS

C D Nazri<sup>1</sup> MSc BSc, I Rodziah<sup>1</sup> MSc BSc, A Hashim<sup>1</sup> MSc BSc

<sup>1</sup> Department of Environmental Health, Faculty of Health Sciences, Universiti Teknologi MARA, Malaysia

**Correspondence:** Nazri Che Dom, Department of Environmental Health, Faculty of Health Sciences, Universiti Teknologi MARA, Malaysia. Telephone: +60332584312/4447 Email : nazricd@salam.uitm.edu.my

## Abstract

Dengue fever over the last 40 years has become one of the most serious epidemic diseases in Malaysia. In 2005, the number of dengue cases increased dramatically and it became the worst epidemic in the nation's history. Recently, remote sensing and Geographic Information System (GIS) technologies have provided an alternative potential tool for infectious disease surveillance and the control of many types of vector borne diseases. In this study, these technologies were used for the surveillance of infectious diseases particularly on a possible dengue outbreak that had been initiated in 2003. The selected study area was Subang Jaya, an area of rapid urbanisation located about 20 km from Kuala Lumpur. The aim was to identify high risk areas for a dengue outbreak using remote sensing and related datasets in a GIS database. The weighted overlays function was used in the analysis and the modeling process to identify the dengue risk areas.

The environmental factors derived from remote sensing data include land cover/use, topography, Land Surface Temperature (LST) and Normalised Difference Vegetation Index (NDVI), temperature, population density and clinical data of dengue cases collected from various agencies. The results showed that the high risk areas for dengue outbreak were associated with areas of high population density, topographically low land areas and high land surface temperatures (LST). Most of the victims were in residential and commercial areas near construction sites and epidemics usually emerged after days of heavy rainfall followed by high temperature. The environmental factors identified from remote sensing data provide sound indicators of areas that are susceptible to dengue outbreaks and provide the dengue distribution pattern in the study area.

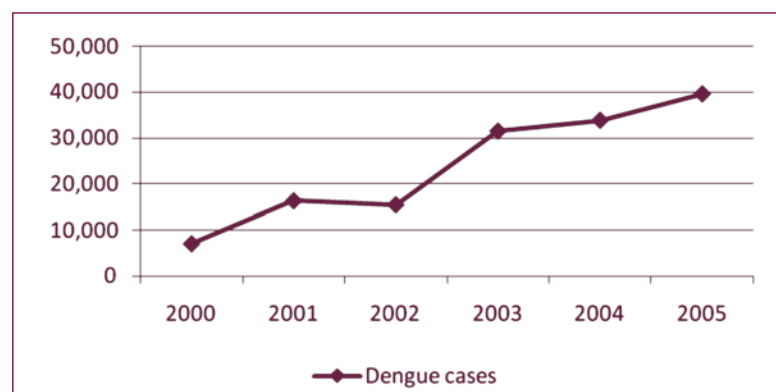
**Key words:** Dengue outbreak; environmental health; environmental factors; Graphical Information Systems; GIS; remote sensing.

## Introduction

Dengue fever has been epidemic in Malaysia since the early 1970s and the number of cases has continued to rise, especially in the late 20th century. Outbreaks usually happen during the rainy season especially when temperatures are high. Barbazan *et al.*, (2002) found two main patterns, which might describe the fluctuations of Dengue Haemorrhagic Fever (DHF) incidences. In a cyclic pattern, incidences of dengue are high during the annually hot and rainy season and this corresponds to seasonal variations of transmission. A non-cyclic pattern shows increases of DHF cases for a variable duration separated by periods of fewer cases lasting two to five years.

It is a challenge for the public health system in Malaysia to make sure an epidemic of this scale does not reoccur. The Malaysian Ministry of Health has reported that the high incidence of dengue in this country was probably owing to an increase in potential mosquito breeding places such as construction sites, clogged drains and accumulated rubbish heaps. The number of construction areas may influence the increase of dengue cases in urban areas. The incidence of dengue is greatest in developed states with a high population density, rapid development and many construction sites.

According to the World Health Organization (WHO, 1997) the interactions between temperature and rainfall are important as determinants in a dengue transmission, as cooler temperatures affect the survival of adult



**Figure 1.0**  
Dengue cases reported in Malaysia for year 2000-2005.

mosquitoes, thus influencing transmission rates. Furthermore, rainfall and temperature may affect patterns of mosquitoes feeding and reproduction, and hence the population density of vector mosquitoes.

Previous studies have identified a number of key factors that contribute to a dengue outbreak. WHO (1997) mentioned that in areas of high human population density, many people might be exposed, even if the mosquito house index shows a low-density value (low mosquito numbers). Distances between houses may thus be of an epidemiological significance, especially in densely packed housing areas. The intensity of dengue transmission varies with the population density of the vectors present, the numbers of non-immunised people and the number of individuals ill with the disease.

The aims of this study are (i) to identify the environmental factors that contribute to the dengue outbreak using remote sensing data; (ii) to correlate the identified environmental factors with dengue occurrence pattern; and (iii) to predict potential high risk areas for a dengue outbreak.

### Remote sensing and GIS

Recent advances in remote sensing technology have provided crucial information on Dengue transmission. Remote sensing provides up to date information on soil moisture, vegetation type, land cover/use, urban planning, crop monitoring, forestry, water and air quality that influence the vector borne disease occurrences. Maynard (2002) found that many of the environmental factors connected to the public health issues are observable through remote sensing, such as air and water quality, thermal extremes, ultraviolet radiation, oceanic harmful algal blooms, as well as pollutant/pathogen transport and deposition via the atmosphere, oceans, ice and rivers. The application of remote sensing together with GIS in health studies has increased especially in the monitoring, surveillance or risk mapping of vector-borne diseases. Most of these studies used remote sensing data to explore the environmental factors that might be associated with disease-vector habitats and human transmission risk.

A Geographic Information System (GIS) is a computer-aided database management and mapping technology that acquires, organises stores and integrates large amounts of multi-purpose information from different sources, programmes and sectors. GIS adds the dimension of geographic analysis to information technology by

providing an interface between the data and a map. Tasks such as temporal modelling of climate changes, environmental degradation, disease transmission and other factors relevant to an outbreak can then be easily analysed. This provides rapid information to key decision-makers quickly, efficiently and effectively.

## Methodology

The methodology used in this study comprised five major parts; data acquisition, pre-processing, processing, creating a GIS database and spatial analysis and modeling. Satellite data of IKONOS, SPOT, Radarsat and Landsat-TM were processed and analysed to produce information on landcover/landuse changes, Land Surface Temperature (LST), Normalised Difference Vegetation Index (NDVI), and Digital Elevation Model (DEM). Environmental factors such as rainfall, temperature, population density and clinical data of dengue cases were integrated into the GIS database. This data was then correlated using the GIS spatial analysis, Weighted Overlay function and modeling techniques in order to identify potential high risk areas for a dengue outbreak. The Weighted Overlay function is a technique for applying a common measurement scale of values to diverse and dissimilar inputs in order to create an integrated analysis.

### Study area

Subang Jaya is a district in the state of Selangor with an area size of 181 km<sup>2</sup>. It is located from from 3° 05' 48.74" N 101° 33' 02.39" E to 2° 58' 22.93" N 101° 44' 39.69" E. The Subang Jaya Municipality was selected as the study area because of the high occurrence of dengue disease in that area. It is surrounded by areas of rapid development and has a high population density ratio of 437,121 per km<sup>2</sup> (Population and Housing Census of Malaysia 2000).

### Environmental parameters

The first major phase of the data collection was to identify the environmental factors, which had significantly influenced the dengue distribution pattern (e.g. land use, slope, vegetated or non vegetated areas and housing types). All of the environmental data was generated from remote sensing data. This technique has been tested successfully by Connor *et al.*, (1996)

Four environmental parameters were identified (land use, NDVI of vegetated and nonvegetated areas, LST and population density).

# Distribution pattern of a dengue fever outbreak using GIS

## Land use map

The land use map was derived from IKONOS (1 meter spatial resolution) imagery using supervised classification. It was classified into nine classes, which includes cleared land, construction, and industrial, commercial, recreational, residential, green area, oxidation pond and water body.

## Normalised Difference Vegetation Index (NDVI)

The NDVI map was derived from the Landsat-TM image by using the visible and near infra-red bands. NDVI information was used to differentiate vegetated areas from non-vegetated areas. Topographical information was used to indicate low land areas, which were prone to forming stagnant water pools. These stagnant water pools could provide suitable mosquito breeding sites. To detect such topographical high or low land areas, satellite radar data was used to generate a Digital Elevation Model (DEM) of the study area.

## Land Surface Temperature (LST)

Land Surface Temperature (LST) information was derived from the Landsat-TM dataset using the thermal band (band 6) that has the radiance value of the land surface. Band 6 is converted into radiance with the following formulae (NASA, 2003):

$$L_{\pi} = \text{"gain"} * QCAL + \text{"offset"}$$

This is also expressed as:

$$L_{\pi} = \frac{(LMAX_{\pi} - LMIN_{\pi} * (QCAL - QCALMIN)) + LMIN_{\pi}}{(QCALMAX - QCALMIN)}$$

The spectral radiance was converted into satellite temperature brightness using the following relationship.

$$T = K2 / \ln(K1 / L_{\pi} + 1)$$

Where:

- T** = Effective at satellite temperature in Kelvin
- K2** = 1282.71 Kelvin
- K1** = 666.09 watts/ (metre squared \* ster \*  $\mu$ m)
- L** = Spectral radiance in watts / (metre squared \* ster \*  $\mu$ m)

## Epidemiological data:

The second phase involves data collection on dengue incidence cases of the year 2006 from MPSJ and the Malaysian Ministry of Health. Sample cases with detailed information such as name, gender, address, serology status, date admitted in hospital and so on were included

in the analysis. This data included information about all the suspected and confirmed DF/DHF cases reported during the year 2006 in the MPSJ district. Data on population density was obtained from the Statistical Department.

## Data Analysis:

Each of the four variables was tested using the weighted overlay function technique in the ArcGIS software. This technique is usually used for applying a common measurement scale of values to diverse and dissimilar inputs in order to create an integrated analysis. The priority value was ranked as low, medium and high (1 to 3) for each variable. A low value means the sub variable had a low intensity influence; a medium value equated to a greater risk influence to the outbreak and a high value equated to a very significant influence on the dengue outbreak pattern. The detailed weighting values for all four environmental variables that were identified as an indicator factor of dengue outbreak are presented in Table 1.0.

For the information obtained, the following algorithm was used to develop the dengue risk zone from each environmental indicator as shown below.

## Dengue Risk Zone

$$(\text{Land use (A)}) + (\text{Population Density (B)}) + (\text{NDVI (C)}) + (\text{LST (D)})$$

## Results and discussion

This study found that areas at a high risk of having a dengue outbreak could be identified through the integration of environmental factors derived from remote sensing with other data from GIS analysis and modeling. The weighted overlay function was chosen to create the risk area map. The following sections provide a detailed analysis of the impact of each variable:

### The correlation of environmental factors to dengue distribution

#### Land cover and land use classification

Figure 2.0 shows the land cover and land use information obtained from the IKONOS (1m resolution) images. From the classification result, it was found that most cases occurred in urban areas, followed by mixed horticulture areas and some in construction areas. Just a few cases were reported in the industrial and forested areas. The reason why dengue cases occur mostly in urban areas can be explained by a number of factors. For an urban area, proper infrastructure such as a good

**Table 1.0**  
The Weighting  
value for  
Environmental Risk  
Indicator

No.	Environmental Risk Indicator	Risk Score (Score of 1 equates to low risk and score of 3 to high risk)	
1	Land use	Cleared land (A <sub>1</sub> )	1
		Construction (A <sub>2</sub> )	3
		Industrial (A <sub>3</sub> )	2
		Commercial (A <sub>4</sub> )	2
		Residential (A <sub>5</sub> )	3
		Recreational (A <sub>6</sub> )	2
		Green area (A <sub>7</sub> )	1
		Oxidation pond (A <sub>8</sub> )	1
		Water body (A <sub>9</sub> )	1
2	Population density	Very low (B <sub>1</sub> )	1
		Low (B <sub>2</sub> )	1
		Medium (B <sub>3</sub> )	2
		High (B <sub>4</sub> )	3
		Very high (B <sub>5</sub> )	3
3	NDVI (C)	Vegetation area (C <sub>1</sub> )	1
		Non vegetation area (C <sub>2</sub> )	2
4	LST (D)	Low (D <sub>1</sub> )	1
		Medium (D <sub>2</sub> )	2
		High (D <sub>3</sub> )	3

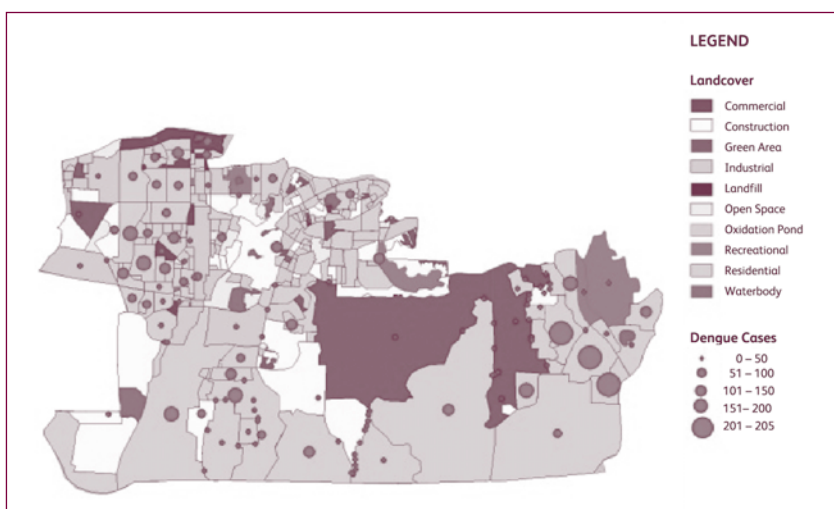
drainage system is very important. A poor drainage system will create pools of stagnant water, which are suitable breeding grounds for mosquitoes. The same problem occurs in construction areas and squatter areas. In areas with a high population density (such as flats, apartments and condominiums), the population density per square metre is high. As a result dengue transmission can and will occur rapidly.

Dengue fever had also been reported in low-density areas (such as high class residential areas and small housing estates). This has been attributed to the fact that as most people like to create mini landscapes or gardens with ponds in their compounds, the ponds can become suitable breeding grounds for mosquito whenever proper preventive methods are not taken. Other areas that also have reported cases of dengue

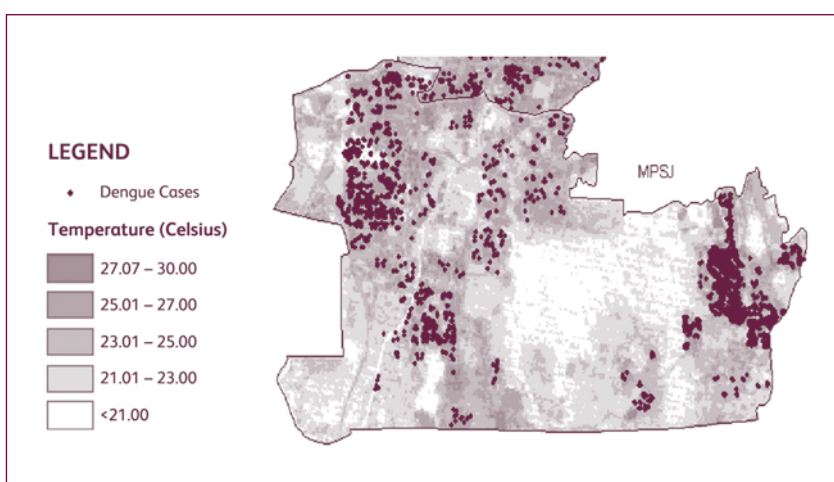
outbreak are areas that are not cleanly maintained, areas that have been left idle, areas with rapid development and areas having temporary structures.

**Land surface temperature (LST)**

The temperature profile of the land surface over the study area is shown on the LST map in Figure 3.0 which was derived from the Landsat TM thermal band (channel 6). The areas with high levels of LST (in red) can be correlated to urban areas, while the white area equate to either a vegetated area or a water body. The LST map shows that the temperature ranges from 21.0°C to 30.0°C. Most of the reported dengue cases occurred in the areas with a temperature range from between 25.0°C to 30.0°C. This temperature range is very conducive to the mosquito breeding cycle as an increase in the number of times that the mosquito



**Figure 2.0**  
Land cover vs. dengue cases of Subang Jaya



**Figure 3.0**  
The distribution of Land Surface Temperature from Landsat TM.

breeds will also increase the likelihood of the emergence of the dengue outbreak.

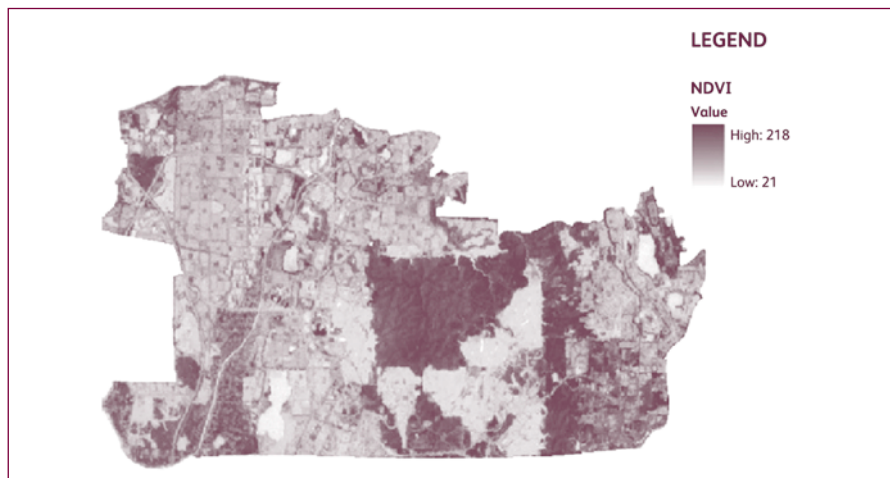
Normalised Difference Vegetation Index (NDVI): NDVI is usually used to derive the vegetation index from satellite images. For this study, it was used to identify the green areas over the study area. Figure 4.0 shows that the range of NDVI values in the study area are between 21 and 218. Built-up areas are shown in white, while the green areas refers to the vegetation density of an area. This study found that the vegetation density ('greenness') of an area was not a major factor in influencing the number of dengue incidences.

### The relationship between other ancillary data with the dengue incidence

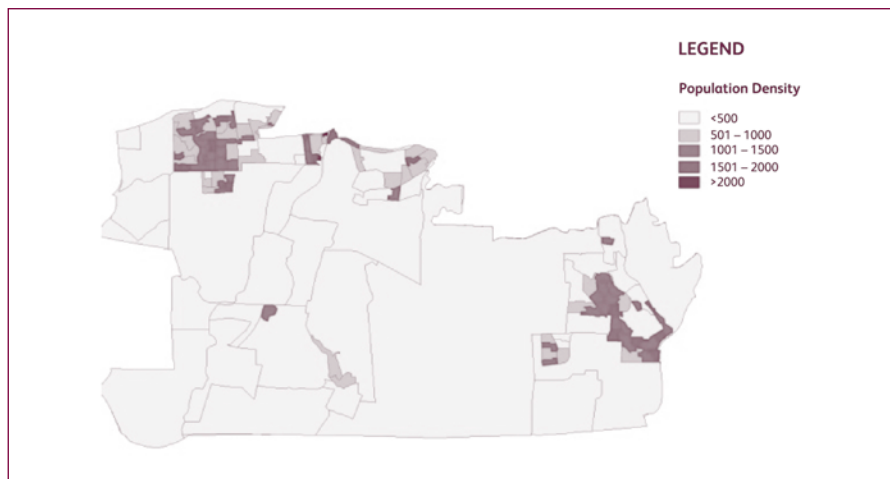
**Analysis of dengue incidence with population density**  
Population density in any urban area is another factor that has to be taken into account in preventing an outbreak of dengue fever. Therefore in this study we used IKONOS images to determine areas with a dense population in the district of Subang Jaya. These areas have their own unique characteristics that are easily identifiable and can be located visually. Population data was also used to verify the result. A densely populated area stands a higher chance of experiencing a dengue outbreak even if the mosquito house index in that area is low. This is because



**Figure 4.0**  
Normalised  
Difference  
Vegetation Index  
(NDVI) map



**Figure 5.0**  
Population density  
map of Subang  
Jaya



the *Aedes aegypti* mosquito does not have to travel far to search for its victims. Therefore an outbreak of dengue fever can and will be able to spread rapidly in such an area.

**Identification of Dengue High Risk Areas in Subang Jaya**

Identification of areas with a high risk of having a dengue outbreak requires the input of the above stated parameters for this analysis. The analysis results of the parameters were then given a specific priority value based on the requirements of this study. The priority values were ranked as ‘low’, ‘medium’, ‘high’ and ‘very high’. The contribution of these values in every spatial layer were given a value between 1 (low) to 4 (very high), where a value of 1 means a very low

contribution while a value of 4 means a very high contribution to the dengue outbreak. Areas with the highest score can then be identified as being areas with a very high risk of having a dengue outbreak.

The potentially high risk areas for the occurrence of dengue incidences over the study area are shown in Figure 6.0. Reported dengue cases data obtained from MPSJ was used to verify the above result. The identified ‘very high risk’ areas are Seri Serdang, Seri Kembangan and USJ. The result shows a strong correlation between locations of reported dengue cases with the potential high risk area map, which was created based on environmental factors used to identify dengue outbreak risk areas.





**Figure 6.0**  
Risk area of dengue fever outbreak

## Conclusions

- Remote sensing satellite data such as Landsat TM, SPOT, Radarsat and IKONOS are capable of providing information on the environmental factors: land cover/use, land surface temperature (LST), NDVI and topography, which are influential to a dengue outbreak. The high risk areas for a dengue outbreak are significantly correlated with environmental factors obtained from remote sensing data which were then integrated with rainfall, temperature, humidity and population density data.
- The study found that most of the victims were staying in the densely populated commercial areas near the construction sites, which were located at topographically low land areas with surrounding high values of land surface temperature (LST). The epidemic normally occurred in these types of areas after days of heavy rainfall followed by high temperature.
- Remote sensing and GIS technologies were found to be an important tool for the effective surveillance and prediction of the dengue outbreak in order to reduce the number of dengue cases. GIS analysis has the ability to model a risk map of dengue distribution through the use of the weighted overlay function, which enabled the users to easily identify high risk areas in a short time period. This initial finding points the way to the wider application of this technology by the relevant authorities to improve monitoring of potential future dengue outbreaks.

## Acknowledgements

The authors would like to thank the Director of Majlis Perbandaran Subang Jaya (MPSJ) for providing ground data on dengue cases for this research work. The contribution of meteorological data from the Malaysian Meteorological Department is also duly acknowledged. Appreciation is also extended to Professor Abu Hassan Ahmad, Dean, School of Biological Sciences, Universiti Sains Malaysia, Malaysia, for his advice.

## References

- Alharthy A** (unpublished). Role of GIS in Dengue Control Management Strategy at Jeddah. Jeddah Municipality, Jeddah, Saudi Arabia. Available online at: [www.saudigis.org/FCKFiles/File/33\\_E\\_AbdullatifAlharthy\\_KSA.pdf](http://www.saudigis.org/FCKFiles/File/33_E_AbdullatifAlharthy_KSA.pdf) [accessed 28/09/09]
- Barbazan P, Amrehn J, Dilokwanich S, Gonzalez J-P, Nakhapakorn K, Oneda K, Thanomsinra A, Yoksan S** (unpublished). Dengue Haemorrhagic Fever (DHF) in the Central Plain of Thailand. Remote sensing and GIS to identify factors and indicators related to dengue transmission. Available online at: [http://std.cpc.ku.ac.th/delta/conf/Acrobat/Papers\\_Eng/Volume%201/Ba rbazan.pdf](http://std.cpc.ku.ac.th/delta/conf/Acrobat/Papers_Eng/Volume%201/Ba rbazan.pdf) [accessed 28/09/09].
- Department of Statistics Malaysia** (2001). Population and Housing Census of Malaysia 2000. Available online at: [www.statistics.gov.my/eng/](http://www.statistics.gov.my/eng/) [accessed 28/09/09]

**Cringoli G, Taddei R, Rinaldi L, Veneziano V, Musella V, Cascone C, Sibilio G, Malone J B** (2004). Use of remote sensing and geographical information systems to identify environmental features that influence the distribution of paramphistomosis in sheep from the southern Italian Apennines. *Veterinary Parasitology*, 122, 15-26.

**Gong Peng X B** (2006). Remote sensing and geographic information systems in the spatial temporal dynamics modeling of infectious diseases. *Science in China Series C: Life Sciences*, 49, 573-582.

**Haja Andrianasolo S Y P** (2001). Remote sensing in unravelling complex associations between physical environment and spatial classes of emerging viral disease. 22nd Asian Conference on Remote Sensing. Singapore, 5-9 November 2001.

**Krishna Prasad Bandari P R** (2008). Application of GIS modelling for dengue fever prone areas, based on socio-cultural and environmental factors – A case study of Delhi City Zone. *The International Archive of The Photogrammetry, Remote Sensing and Spatial Information Sciences*, XXXVII, 165-170.

**Maynard N G** (2002). Remote sensing for the public health surveillance and response. *Earth Observation Magazine*. Special NASA Earth Science Enterprise Issue, pg 43-45. Available online at: [www.aarsacrs.org/acrs/proceeding/ACRS2007/Papers/TS27.4.pdf](http://www.aarsacrs.org/acrs/proceeding/ACRS2007/Papers/TS27.4.pdf) [accessed 28/09/09].

**Napier M** (2003). Application of GIS and modeling of Dengue Risk Areas in the Hawaiian Islands. Pacific Disaster Center, 590 Lipoo Parkway Suite 259 Kinei, HI. Available online at: [www.pdc.org/PDCNewsWebArticles/2003ISRE\\_Napier\\_TS49.3pdf](http://www.pdc.org/PDCNewsWebArticles/2003ISRE_Napier_TS49.3pdf) [accessed 28/09/09].

**Openshaw S** (1996). Geographical information systems and tropical diseases. *Transactions Of The Royal Society Of Tropical Medicine And Hygiene*, 90, 337-339.

**Ratana Sithiprasasna K J** (1997). Use of GIS to study the epidemiology of Dengue Haemorrhagic Fever in Thailand. *Dengue Bulletin*, 21, 68-73.

**Schroder W** (2006). GIS, geostatistics, metadata banking, and tree-based models for data analysis and mapping in environmental monitoring and epidemiology. *International Journal of Medical Microbiology*, 296, 23-36.

**Song G T I** (2000). The use of GIS in Ovitrap Monitoring for Dengue control in Singapore. *Dengue Bulletin*, 24, 110-116.

**Tripathi K N** (2005). An information value based analysis of physical and climatic factors affecting dengue fever and dengue haemorrhagic fever incidence. *International Journal of Health Geographics*, 4, 4-13.

**Tzai-Hung Wen N H H C D** (2006). Spatial mapping of temporal risk characteristics to improve environmental health risk identification: A case study of a dengue epidemic in Taiwan. *Science of the Total Environment*, 367, 631-640.

**Valerie Crossa A F** (2000). Fuzzy objects for geographical information systems. *Fuzzy Sets and Systems*, 113, 19-36.

**Wong Ngai Szea L C** (2007). An alert system for informing environmental risk of Dengue infectious. GIS for Health and the Environment, Part 7, 171-183, Berlin, Springer.

# The impact of chemical treatments on the wear, gloss, roughness, maintenance, and slipperiness of glazed ceramic tiles

Dr François Quirion<sup>1</sup>, André Massicotte<sup>1</sup>, Sophie Boudrias<sup>1</sup>, Patrice Poirier<sup>1</sup>

<sup>1</sup> QI Recherche et Développement Technologique Inc.

**Correspondence:** Dr François Quirion, QI Recherche et Développement Technologique Inc., 10301 Avenue Pelletier, Montréal, Québec, Canada, H1H 3R2.  
Telephone: +1 514 272-6040. E-mail: francois.quirion@qinc.ca

## Abstract

Glazed ceramic tiles are known to be slippery when wet and many surface treatments are offered on the market to improve their slip resistance. Surprisingly, there are very few systematic investigations of the impact of these surface treatments on the slip resistance and surface properties of these tiles. Among the most common treatments are those based on hydrofluoric acid and those based on ammonium bifluoride. In this investigation, these two treatments were applied to glazed ceramic tiles and the impact on the mass loss, resistance to abrasive wear, average roughness, gloss, ease of maintenance, dry and wet friction and aquaplaning threshold was evaluated.

Scanning electron microscopy of the treated glaze suggests that the hydrofluoric acid treatment dissolves part of the glaze and leaves holes at the surface while the ammonium bifluoride treatment leaves a layer of submicron particles on top of the glaze. The glaze treated with hydrofluoric acid is more fragile and sensitive to abrasive and maintenance wear than the untreated tiles. The layer of submicron particles does not adhere strongly to the glaze and it wears out quite easily. The microscopic changes at the surface of glazed tiles have little impact on the average roughness but they slightly increase the slip resistance of the treated tiles. However, the treatments also reduce the gloss and make the tiles more difficult to clean.

**Key words:** Bifluoride; chemical etch; environmental health; fluorhydric acid; friction; glazed ceramic tiles; slips and falls; slippery floors.

## Introduction

Smooth glazed ceramic tiles are known to be slippery when wet. For instance, Cholet *et al.*, (2000) investigated the friction of different flooring using various apparatus and the friction of the smooth and glazed ceramic tiles was always among the lowest. Even so, glazed ceramic tiles are still found in bathrooms, kitchens and halls where they are likely to become wet and slippery. When slips and falls occur, the owners usually prefer to apply a treatment on their slippery floor because it is less expensive than replacing it by non slippery tiles. Many options, including chemical treatments based on either hydrofluoric acid, HF, or ammonium bifluoride, ABF, are offered on the market.

It was suggested by Chang *et al.*, (2001) that friction depends not only on the macroscopic texture of a

surface but also on its microscopic texture. In the UK, HSL (Lemon and Worth, 2008) has developed a 'slip assessment tool' based on the measurement of surface micro-roughness. Interestingly, most manufacturers of the chemical treatments claim that their product generates roughness at the micro-level. Surprisingly, there are very few investigations of the impact of these chemical treatments on the slip resistance and roughness of glazed ceramic tiles.

Grönqvist *et al.*, (1992, 2003) reported a significant increase of the wet friction of a glazed ceramic tile after a treatment with a solution of ammonium bifluoride at 5% in water. The increase in wet friction was accompanied by an increase of the micro-roughness.

Bowman *et al.*, (2002) report friction measurements with various methods on a polished porcelain tile treated with a "proprietary floor surface etching treatment" but the chemical nature of the treatment and the application procedure are not described. They observed a significant loss of gloss and that "the SATRA STM 103, Pendulum and wet barefoot ramp tests were all able to determine an improvement in the slip resistance of the etched polished porcelain tile. The VIT and oil-wet ramp tests were unable to detect an improvement". They also mention that these conclusions are contrary to those of Di Pilla (2000) who used the same VIT to emphasise the improvement of the wet friction of glazed ceramic tiles treated with various products.

In Di Pilla's study (2000), the surface treatment was applied by the vendors and the nature and the application procedure of these treatments are not given. Nevertheless, they find that some treatments drastically improve the wet friction of glazed ceramic tiles while others have little or no effects. However, they also mention that "there appeared to be low correlation between product claims and the efficacy of the product". Di Pilla (2000) finally concludes that "more work needs to be done in evaluating the efficacy of these products".

These results, sometimes contradictory, raise some questions on the efficacy of chemical treatments to improve the slip resistance of glazed ceramic tiles. Moreover, they do not answer the questions related to the impact of these treatments on the resistance to wear, the roughness, the gloss and the ease of maintenance of the treated tiles. In this investigation, we present a systematic investigation of the impact of hydrofluoric acid and ammonium bifluoride treatments on the surface properties of glazed ceramic tiles.

### Chemical treatments and tiles tested

All the experiments described in this article were performed in our laboratory using glazed ceramic tiles and chemical treatments available commercially. Two types of chemical treatment were tested. The first one contains hydrofluoric acid in an aqueous surfactant solution and the second contains ammonium bifluoride in a surfactant solution. For comparison purposes, some tiles were treated with either water or a neutralised solution of the hydrofluoric acid treatment.

#### **Hydrofluoric acid treatment, HF**

Titration with sodium hydroxide confirms the presence of 17.2 % (w/w) of HF in the commercial product. As indicated on the label, the treatment was performed with a solution consisting of one part of the product and one part of tap water, resulting in a solution containing 8.6% HF. That solution was applied on the surface of the glazed ceramic tiles (~ 400 ml/m<sup>2</sup>) and scrubbed gently with a piece of red floor pad to maintain the surface wet for the duration of the treatment (20 minutes). After the treatment, the tiles were rinsed thoroughly under running water, without any neutralisation, and dried at room temperature. The tiles treated in that manner are referred to as HF tiles.

#### **Ammonium bifluoride, ABF**

The glazed ceramic tiles were treated with two commercial products containing ammonium bifluoride. The results were very similar and they are combined without distinction in this investigation. Assuming that 2 moles of sodium hydroxide (NaOH) are required to neutralise ABF (NH<sub>4</sub>HF<sub>2</sub>), titration of both products led to a concentration of 1.25 % (w/w) of ABF. As recommended by the manufacturers, approximately 400 ml/m<sup>2</sup> of the product was applied directly on the glazed ceramic tiles. The samples were scrubbed gently with a piece of red floor pad to maintain the surface wet for the duration of the treatment (40 minutes). The samples were then rinsed thoroughly under running water, without any neutralisation, and dried at room temperature. The tiles treated in this manner are referred to as ABF tiles.

#### **Blank treatment, BLANK**

The blank treatment is essentially a treatment that is performed in the same manner as the HF or ABF treatments but with water or a neutralised solution of the HF treatment. The blank solution was applied on the glazed ceramic tiles at a surface concentration of ~400 ml/m<sup>2</sup> and scrubbed gently with a piece of red floor pad to maintain the surface wet for the duration of the

treatment (20 minutes). The samples were then rinsed thoroughly under running water and dried at room temperature. These tiles are referred to as BLANK tiles.

#### **Glazed ceramic tiles**

All the results presented in this investigation were obtained with glazed ceramic tiles (Cecrisa, White Basic Matte, PEI = 4, 20 cm x 20 cm or Portobello, ARQ NEVE, PEI = 3, 7.2 cm x 7.2 cm). The Cecrisa tiles were cut to the required size while the Portobello tiles were used as received. Six surface conditions were tested. The first three correspond to the tiles treated with the BLANK, HF or ABF treatment. The other three correspond to the tiles treated and worn mechanically.

## Methodology

The methods used to evaluate the impact of the chemical treatments on the surface properties and slipperiness of glazed ceramic tiles are described below.

### **Wear**

In this investigation, wear corresponds to the mass loss caused by an action performed on the surface of the glazed ceramic tiles and it is expressed in g/m<sup>2</sup>.

#### **Abrasive wear**

Abrasive wear simulates the wear caused by traffic. Experimentally, the sample tiles were sanded twice for 20 seconds each time with an orbital sander (Al<sub>2</sub>O<sub>3</sub>, grit 220) with the pressure from the weight of the sander (1.2 kg). The abrasive wear is determined as the mass difference before and after sanding. The test is rather soft but it allows us to identify very fragile surfaces.

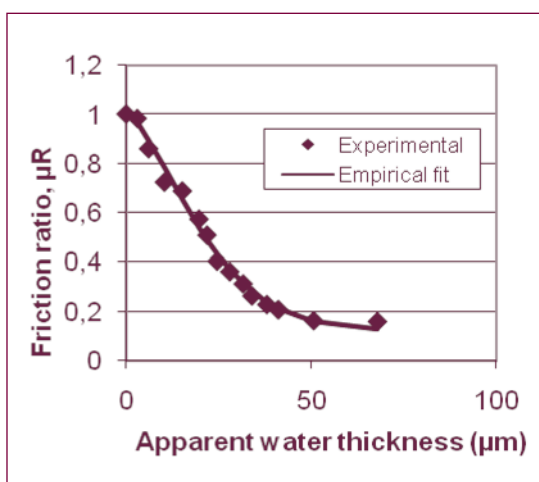
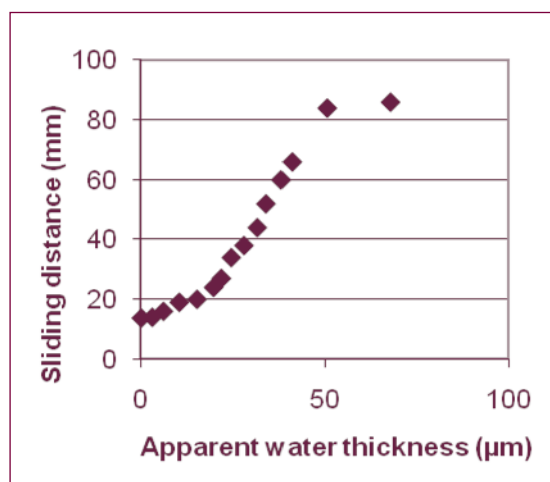
#### **Chemical wear**

Chemical wear corresponds to the mass loss, g/m<sup>2</sup>, caused by treating the surface of the tiles with either the chemical or the blank treatments (see section above for details). The mass is measured before the treatments and after the tiles were treated and dried at 24 ± 1°C for at least 18 hours.

#### **Maintenance wear**

Maintenance wear corresponds to the mass loss through daily floor cleaning of the initially clean tiles. The maintenance wear was determined for damp mopping of the treated tiles with either water or a neutral floor cleaner (0.15% nonylphenol ethoxylate in tap water, pH ~10, T ~23°C) and machine scrubbing at 175 RPM with the neutral floor cleaner and a red floor pad (diameter of 43 cm). The maintenance wear is

# The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles



**Figure 1.0**  
Example of the analysis of data generated by the Falling Plate Method.

The left side presents the sliding distance of a Neolite plate on an HF tile as a function of the apparent water thickness. The right side shows the friction ratio,  $\mu_R$  (calculated with the sliding distances and equation 1) and the best fit obtained with equation 2 (Fitting parameters are  $\mu_{R,\infty} = 0.12$ ,  $\alpha = 1.5$  and  $t^* = 24 \mu\text{m}$ ).

expressed as the mass loss,  $\text{g}/\text{m}^2$ , following the equivalent of six months of daily floor cleaning.

## Gloss

Gloss is a measure of the reflectivity of light on a surface. Experimentally, a red light beam (630 nm) was projected at an angle of  $45^\circ$  on the surface of the sample tiles and the intensity of the light reflected at  $45^\circ$  was measured using a photo resistive cell. In this investigation, the reflectivity of a given tile is expressed as the percentage of the reflectivity of the BLANK tiles. If the reflectivity of a tile,  $R$ , is lower than 100%, then its gloss is lower than the gloss of the BLANK tiles. The reflectivity is always the average of five measurements at five different locations on a tile and the standard deviation from tile to tile was typically  $\pm 1\%$ , except for the tiles treated with HF where it is around  $\pm 2\%$ .

## Ease of maintenance of the tiles (EM)

To determine the ease of maintenance, a given amount of vegetable oil was spread homogeneously on the Portobello tiles, which were then cleaned using a procedure developed in our laboratory to simulate damp mopping (Quirion, 2004). The cleaned tiles were then dried at room temperature and weighed to determine the residual amount of oil left after cleaning. The ease of maintenance,  $EM$ , of a given tile is defined as the ratio of the residual amount of oil on that tile to the residual

amount of oil on the BLANK tiles.  $EM$  increases from 0 to 1 with 1 being the ease of maintenance of the BLANK tiles. If  $EM < 1$ , then the tiles are more difficult to clean than the BLANK tiles. For these experiments, the floor cleaner was an anionic degreaser containing sodium dodecylbenzene sulfonate and 2-butoxyethanol diluted at 0.4% in tap water with a pH  $\sim 11$ .

## The Falling Plate Method: Aquaplaning threshold, $t^*$ , and wet friction, $\mu_{\text{wet}}$

The Falling Plate Method is detailed in an earlier paper (Quirion and Poirier, 2007). In summary, a flat and thin Neolite plate standing perpendicular to a wet tile is tilted until it falls freely on the tile. After the plate hits the surface, it slides over a given distance,  $d$ . The Neolite plate is 64 mm high, 41 mm wide and it weighs 76 g. The average roughness of the Neolite surface was kept around  $Ra = 0.6 \pm 0.2 \mu\text{m}$  over the period of the investigation.

The sliding distance was measured on the dry tiles and as a function of the amount of water on the surface of the tiles. The amount of water is expressed as a liquid thickness,  $t$ , ( $1 \text{ ml}/\text{m}^2 = 10^{-6} \text{ m}^3/\text{m}^2 = 10^{-6} \text{ m} = 1 \mu\text{m}$ ). It is well known (Rabinowicz, 1995) that the sliding distance is correlated with the reciprocal of the friction coefficient,  $\mu$ . Thus, the ratio of the dry,  $d_{\text{dry}}$ , and wet,  $d_{\text{wet}}$ , sliding distances should be correlated with the ratio,  $\mu_R$ , of the wet,  $\mu_{\text{wet}}$ , and dry,  $\mu_{\text{dry}}$  friction coefficients (equation 1).

**Table 1.0**

Chemical wear (g/m<sup>2</sup>) of Cecrisa and Portobello ceramic tiles following different treatments. The Portobello tiles were treated by two different operators using the same procedure.

	Cecrisa	Portobello 1	Portobello 2
BLANK	0.1 ± 0.1	0.4 ± 0.1	0.45 ± 0.06
HF	3.5 ± 1.3	10.5 ± 1.8	12.4 ± 1.5
ABF	-0.6 <sup>1</sup> ± 0.4	-0.2 ± 0.2	-0.5 ± 0.6

<sup>1</sup> Negative values correspond to an increase in the mass of the test sample

$$\mu_R = \frac{\mu_{wet}}{\mu_{dry}} = \frac{d_{dry}}{d_{wet}} \quad [1]$$

$$\mu_R = \mu_{R,\infty} + (1 - \mu_{R,\infty}) \cdot \exp - (t/t^*)^a \quad [2]$$

Figure 1.0 shows a typical  $d$  vs.  $t$  data set obtained on a HF tile. As  $t$  increases, water fills the valleys and the sliding distance increases. Eventually, the surface of the tile becomes saturated with water and the sliding distance reaches a plateau. Figure 1.0 shows that the relative friction ( $\mu_R$ ) remains constant and low at high water thickness, in accordance with the concept of aquaplaning. The thickness of liquid required to reach that plateau is thus called the aquaplaning threshold,  $t^*$ , and it was obtained by fitting each independent  $\mu_R$  vs.  $t$  data set to equation 2 ( $\mu_{R,\infty}$  is the friction ratio at  $t = \infty$  and  $a$  is an exponent that accounts for the rate of friction drop). Note that  $t^*$  can also be obtained by fitting equation 2 to  $\mu_{wet}$  vs.  $t$  data sets, provided that one knows the value of  $\mu_{dry}$  to get  $\mu_{wet}$  from equation 1.

Typically, one  $\mu_R$  vs  $t$  data set consisted of 10 to 15 sliding distances obtained in the range  $t = 8$  to 100  $\mu\text{m}$  of water. The values of  $t^*$  reported in this paper are the average of two to six independent data sets.

**Dry friction and wet friction**

The dry friction was determined by pulling the Neolite slider on the dry tiles at a velocity around 22 mm/sec. The dynamic coefficient of friction corresponds to the ratio of the pulling force to the weight of the slider. The friction coefficient of one tile corresponds to the average of five determinations and the values of  $\mu_{dry}$  reported in this investigation are the average of at least two tiles. The wet friction,  $\mu_{wet}$ , was evaluated from the Falling Plate Method results using the dry friction of the Neolite slider and equation 1.

The dry and wet frictions were also obtained at a higher load using the Brungraber Mark II apparatus equipped

with the Neolite slider used for the Falling Plate Method. Initially, the foot of the Mark II was tilted so that its rear end was in contact with tile. As the weight was released, the slider fell on the tile in a manner very similar to the Falling Plate Method, but this time with a much higher load. That procedure was used to determine the friction under dry and wet conditions.

**Average roughness (Ra)**

The average roughness,  $Ra$ , was determined with a DekTak 3030 equipped with a diamond stylus having a tip radius of 12.5  $\mu\text{m}$ . The measurement proceeded at low speed over a length of 5 mm with a 0.05 mN (5 mg) force applied on the stylus. The value of  $Ra$  was determined on five locations of a tile and the values reported are the average of 2 to 6 sample tiles.

**Results**

This section compares the wear, gloss, roughness, slipperiness and ease of maintenance of glazed ceramic tiles treated with a solution of hydrofluoric acid or ammonium bifluoride or with a blank solution (no active ingredients).

**Wear of glazed ceramic tiles**

The wear is associated with the mass loss caused by the chemical treatments, the abrasion from traffic and the maintenance of glazed ceramic tiles.

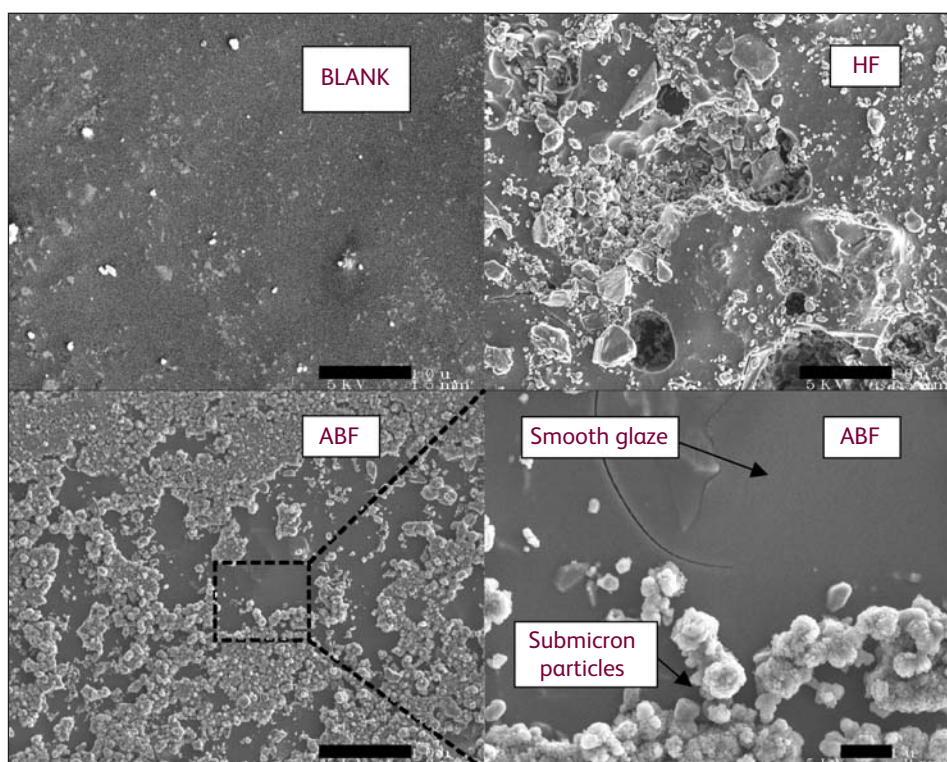
**Chemical wear**

The chemical wear for BLANK, HF and ABF tiles was determined for Cecrisa and Portobello tiles and the results are compared in Table 1.0. The Portobello tiles were treated by two different operators using the same procedure and the results are fairly reproducible from one operator to the other.

The first observation is that the chemical wear caused by



## The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles



**Figure 2.0** Scanning electron microscope (SEM) images of the treated Ceccrisa tiles. The black horizontal bar corresponds to 10 µm except for the bottom right image (1 µm) that corresponds to the dashed rectangle of the bottom left image.

the HF solution is much more important than the chemical wear caused by the BLANK treatment. This is true for the Ceccrisa and the Portobello tiles, suggesting that the effect is not limited to one brand of tile. The relatively high mass loss strongly suggests that hydrofluoric acid solubilises part of the glaze which is then washed away during the rinsing step. This was observed by Fang *et al.*, (1997) for ceramics containing  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  and by Lee *et al.*, (2001) during the treatment of alumino-silicate fibres with HF. On the contrary, the treatment with ABF results in a slight increase of the mass, suggesting that a small amount of material is deposited on the tiles.

To better understand the difference between the action of HF and ABF, the surface of the treated tiles was analysed with scanning electron microscopy, SEM. As seen in Figure 2.0, the surface of the BLANK tile is rather smooth with some isolated peaks. After the HF treatment, the glaze presents a lot of holes, differing in size and depth, in accordance with the dissolution of part of the glaze by HF. The ABF treatment results in a thin layer of submicron particles deposited on the smooth glaze. In order to get some information on the chemical

composition of the treated surfaces, the Auger emissions were analysed and the scans are shown in Figure 3.0.

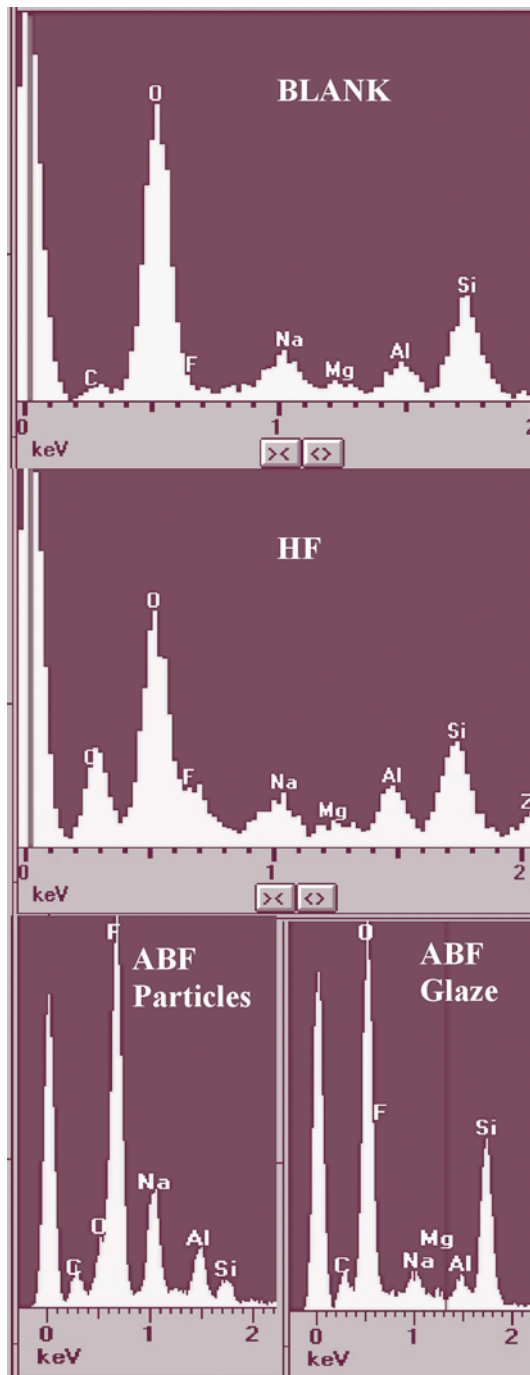
The peaks correspond to the atoms bombarded by the electron beam during the SEM experiments. For the SEM experiments, the surface of the samples is made electrically conductive with a very thin carbon film, which explains the origin of the carbon peak for all the samples investigated.

The peaks of the BLANK tile confirm that the surface of the glaze is mainly composed of silicon and oxygen ( $\text{SiO}_2$ ) and also sodium (Na), magnesium (Mg) and aluminum (Al) which are common atoms in glazes.

After the HF treatment, the glaze still has the same overall composition. This suggests that the glaze exposed by the formation of the holes has the same composition as the original glaze. This indicates that the HF treatment performed in our laboratory does not remove completely the glaze from the surface of the tiles.

As seen in Figure 2.0, the ABF treatment leads to submicron particles deposited on a smooth glaze. The

**Figure 3.0**  
Auger emissions of the treated Cecrisa tiles during the SEM experiments



composition of the smooth glaze is almost the same as that of the BLANK tile. However, the composition of the submicron particles is quite different. They are mainly composed of F, Na, Mg, Al with very little  $\text{SiO}_2$ . Since there is almost no fluorine atom on the original glaze, these results strongly suggest that the submicron particles originate from ammonium bifluoride which contains fluorine ( $\text{NH}_4\text{HF}_2$ ). This explains the mass increase following the ABF treatment.

**Abrasive wear**

The resistance to wear caused by traffic was simulated by sanding the glazed tiles for a brief period of time and the results are expressed in terms of abrasive wear in Table 2.0 for Cecrisa and Portobello tiles.

The abrasive wear is significantly higher for the HF tiles compared to the BLANK tiles suggesting that the HF treatment makes the glaze more fragile. These results are in agreement with Fang *et al.*, (1997) who also observed a faster erosion rate for ceramics containing  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  after they were treated with a solution containing HF.

The mass loss caused by the abrasion of the ABF tiles corresponds fairly well with the mass gained during the ABF treatment, suggesting that the layer of submicron particles is removed from the surface of the glaze during the abrasion test. The abrasion test is rather gentle indicating that the layer of submicron particles does not adhere strongly to the glaze.

**Maintenance wear**

Table 3.0 compares the impact of six month of daily floor cleaning by damp mopping with water or a neutral floor cleaner or by machine scrubbing with a neutral floor cleaner on BLANK and HF Portobello tiles.

Damp mopping with either a neutral floor cleaner or water resulted in a mass loss 19 and 30 times more important for the HF tiles relative to the BLANK tiles. Machine scrubbing with a neutral floor cleaner also removed 19 times more glaze on the HF tiles relative to the BLANK tiles. Once again, this suggests that the surface of the HF tiles is more fragile and sensitive to the action of floor cleaning than the BLANK tiles.

The chemicals present in the floor cleaner do not seem to be responsible for the mass loss because the maintenance with water also results in a significant mass loss. Not too surprisingly, the more aggressive machine scrubbing results in a higher maintenance wear for both the BLANK and the HF treated tiles.



# The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles

	Cecrisa	Portobello
BLANK	0.4 ± 0.2	0.2 ± 0.1
HF	1.1 ± 0.2	1.1 ± 0.1
ABF	0.4 ± 0.1	0.4 ± 0.1

**Table 2.0**  
Abrasive wear (g/m<sup>2</sup>) of treated Cecrisa and Portobello tiles

	Damp mopping with NN	Scrubbing with NN	Damp mopping with water
BLANK	0.22 ± 0.04	0.4	0.20 ± 0.04
HF	4.1 ± 0.8	7.7	5.9 ± 0.6

**Table 3.0**  
Maintenance wear (g/m<sup>2</sup>) of the treated Portobello tiles

Maintenance wear (g/m<sup>2</sup>) of the treated Portobello tiles caused by the equivalent of six months of daily floor cleaning by damp mopping with a neutral floor cleaner (NN) or water and machine scrubbing at 175 RPM with a red floor pad (43 cm) and a neutral floor cleaner.

## Gloss and roughness of glazed ceramic tiles

Glazed ceramic tiles are often chosen because of their high gloss which is associated with smooth and glazed surfaces. This section looks at the impact of the chemical treatments on the gloss and roughness of the glaze.

### Gloss

The gloss is expressed as the percentage of the reflectivity, *R* (%), of the BLANK tiles. Hence, in Table 4.0 the BLANK tiles have a reflectivity of 100 % and a loss of gloss corresponds to a value lower than 100 %.

As expected, the surface changes caused by the HF and ABF treatments reduce the gloss to about 65% of the Cecrisa tiles and 74% of the Portobello tiles. Surprisingly, the magnitude of the effect seems to be similar for the holes (HF tiles) and the submicron particles (ABF tiles). The effect seems to be greater for the smoother Cecrisa

tiles (*R<sub>a</sub>* = 1.4 μm for Cecrisa and 4.4 μm for Portobello). The loss of gloss was also observed by Bowman *et al.*, (2002) after etching glazed porcelain tiles. However, the comparison with our results is difficult since they did not give the nature of the chemical treatment.

Table 4.0 also indicates that abrasive wear has little impact on the gloss of BLANK tiles while it increases the gloss of the HF and ABF tiles. The increase is rather small for the worn HF tiles (+ 4% and + 2%) suggesting that the holes generated by the treatment are deeper than the action of the soft abrasion. The situation is different for the worn ABF tiles for which the gloss increases significantly (+ 20% and + 8%) following the soft abrasion. This corroborates that the layer of submicron particles does not adhere strongly and is easily removed from the smooth glaze. This also suggests that the ABF treatment has a reversible impact on the gloss while the HF treatment would decrease the gloss irreversibly.

	<i>R</i> (%) Cecrisa		<i>R</i> (%) Portobello		<i>R<sub>a</sub></i> (μm) Cecrisa		<i>R<sub>a</sub></i> (μm) Portobello	
	Treated	Treated and worn	Treated	Treated and worn	Treated	Treated and worn	Treated	Treated and worn
BLANK	100	101	100	101	1.4 ± 0.1	1.4 ± 0.2	4.4 ± 0.4	3.7 ± 0.4
HF	65	69	72	74	1.6 ± 0.2	1.3 ± 0.2	4.1 ± 0.4	3.3 ± 0.7
ABF	66	86	76	84	1.8 ± 0.2	1.6 ± 0.1	3.7 ± 0.4	3.5 ± 0.5

**Table 4.0**  
Reflectivity, *R* (%), and average roughness, *R<sub>a</sub>* (μm), of the Cecrisa and Portobello tiles after different treatments

Values of *R* (%) are ± 1 % except ± 2 % for the HF tiles.

### Average roughness

There are many parameters used to express the roughness of a surface (Chang *et al.*, 2004) and most of them depend on the experimental conditions (scan length, tip force, tip radius, horizontal speed, cut-off length, etc.). In this investigation, we used a DekTak profilometer that generates only the average roughness, *Ra*, and the values are reported in Table 4.0. Some may argue that the average roughness is not the best parameter to correlate the roughness of a surface with its wet friction. However, it seems that in certain conditions, *Ra* may be correlated with wet friction. For instance, Loo-Morrey (2007) has reported values of *Ra* and *Rz* for different floor types. We analysed these values and we found a very good correlation between *Ra* and *Rz*. The author mentions that “the value of water-wet PTV (Pendulum Test Value) measurements increases as the *Rz* surface roughness of the natural or man-made stones increases”. Since *Ra* is directly correlated with *Rz*, then one could also say that the water-wet PTV increases with *Ra*. In another report, Loo-Morrey (2006) compared the wet PTV with the wet friction coefficient obtained using the ramp test and it is reported that “the ramp CoF (coefficient of friction) increases as the pendulum CoF increases”. Hence, considering that *Ra* is correlated with the wet PTV and that the wet PTV is correlated with the wet ramp coefficient of friction, then one can assume that *Ra* is also correlated with the wet ramp coefficient of friction, at least for the flooring materials and the experimental conditions described by Loo-Morrey (2006, 2007).

The treatment of Cecrisa tiles with either HF or ABF increases only slightly the value of *Ra*. The results for the Portobello tiles even suggest a slight decrease of *Ra* upon treating the tiles with either HF or ABF. However, the uncertainty on *Ra* for these tiles is quite high so that the effect remains rather insignificant.

Grönqvist *et al.*, (1992) reported an increase of *Ra* from

0.5 to 1.0 µm after the application of an undefined antislip treatment on a glazed ceramic tile. This variation is similar to what we observed (+ 0.2 and + 0.4 µm) for the HF and ABF treatments of the Cecrisa tiles but in disagreement with the decrease (-0.3 and -0.7 µm) observed for the rougher Portobello tiles. In a later study, they reported (Grönqvist *et al.*, 2003) a significant increase of *Rz* from 2.6 ± 0.6 to 5.9 ± 0.9 µm following the treatment of a glazed ceramic tile with a solution of ammonium bifluoride (5 % w/w). Maybe the application of a more concentrated solution of ABF (5 % vs. 1.2 % in our case) leads to a higher increase of the roughness. Or maybe *Rz* is more sensitive to roughness changes than *Ra*.

Using atomic force microscopy Luo *et al.*, (2001) obtained the average roughness, *Ra*, of a dental ceramic rich in SiO<sub>2</sub> following the treatment with hydrofluoric acid (9.6%). For a 20 µm x 20 µm area, the value of *Ra* increased from 6 nm to about 278 nm, suggesting that *Ra* increases by 0.3 µm following the HF treatment. That value is similar to what was observed for the Cecrisa tiles (+ 0.2 µm). But once again, the experimental conditions are too different for any quantitative comparison.

Finally, abrasive wear (treated and worn tiles) appears to reduce the average roughness of the tiles. The effect remains small but it is observed for all the tiles tested, suggesting a definite trend. This decrease of the surface roughness following abrasive wear is in agreement with the increase of the gloss noted in the previous section.

### Slipperiness of glazed ceramic tiles

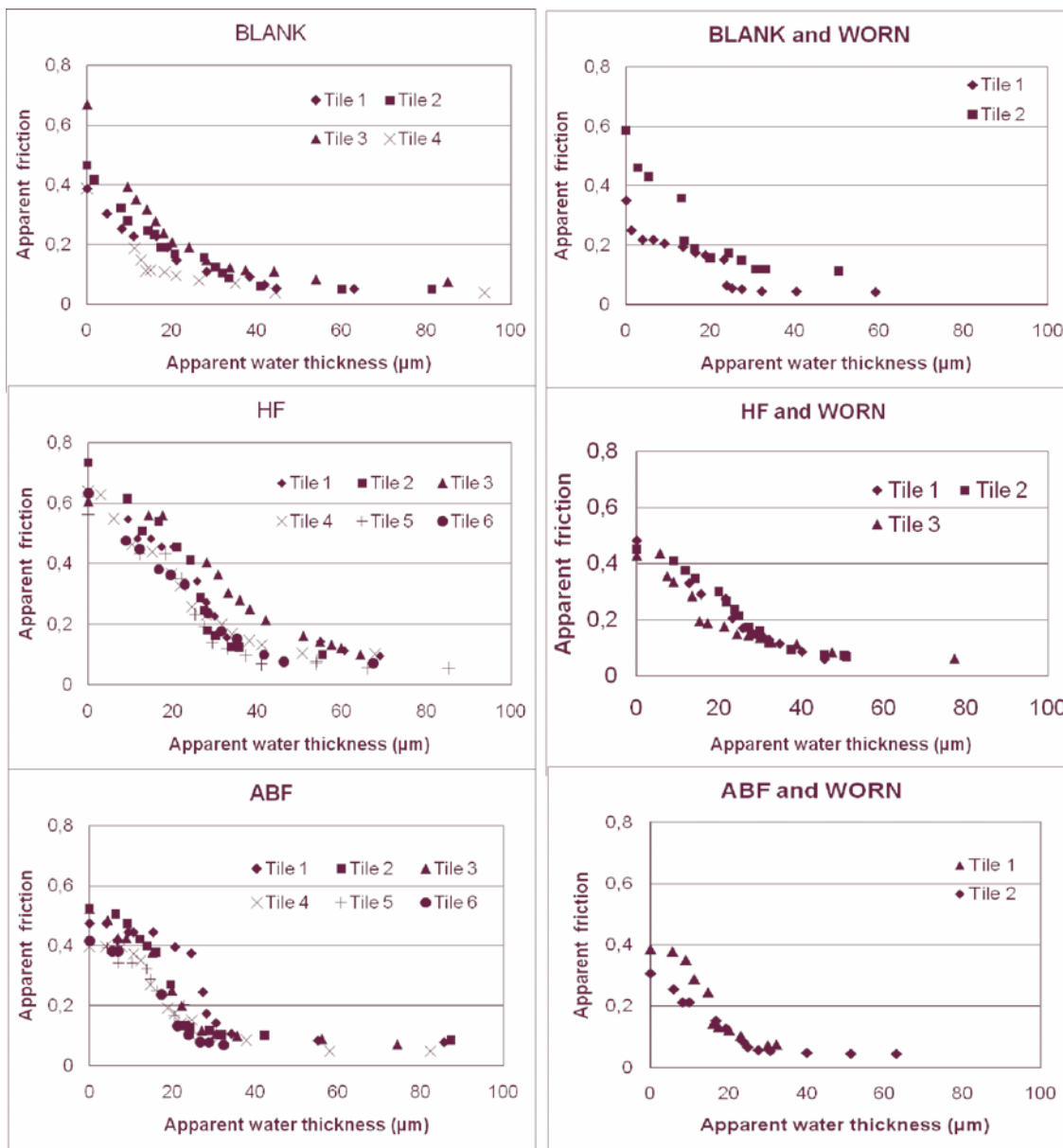
The friction coefficient of a smooth Neolite sample with the glazed ceramic tiles was measured under dry (horizontal pull and Brungraber Mark II) and wet (Brungraber Mark II) conditions. The Falling Plate Method (Quirion and Poirier, 2007) was also used to evaluate the aquaplaning threshold and the wet friction.

**Table 5.0**

Dry friction,  $\mu_{dry}$ , of Neolite on Cecrisa tiles after different treatments. Results were obtained with the Horizontal Pull method and the Brungraber Mark II

	Horizontal Pull		Mark II	
	Treated	Treated and worn	Treated	Treated and worn
BLANK	0.54 ± 0.12	0.47 ± 0.17	0.68	0.72
HF	0.61 ± 0.04	0.49 ± 0.14	0.78 ± 0.07	0.66 ± 0.03
ABF	0.44 ± 0.05	0.40 ± 0.08	0.70 ± 0.05	0.64 ± 0.02

# The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles



**Figure 4.0** Apparent friction,  $\mu_{wet}$ , obtained using the Falling Plate Method with a Neolite slider as a function of the apparent water thickness,  $t$ , on the tiles. Tile numbers only distinguish independent data sets. Results obtained on the treated tiles (Left) are compared with those obtained on worn tiles (Right)

## Dry friction

Table 5.0 summarises the dry friction coefficient obtained with the horizontal pull method and the Brungraber Mark II. The absolute values of the friction coefficient obtained with the horizontal pull method are lower than those obtained with the Mark II apparatus.

However, both methods suggest a slight increase of the dry friction caused by the HF treatment and little impact for the ABF treatment. These results are in agreement with the observations of Di Pilla (2000) who noted only a slight increase of the dry friction of glazed ceramic tiles following different surface treatments.

Once the HF and ABF tiles become worn, their dry friction drops to the same level and sometimes lower than that of the BLANK tiles.

**Aquaplaning threshold**

Table 6.0 reports the average values of the aquaplaning threshold,  $t^*$ , obtained from the analysis of the  $\mu_{wet}$  vs.  $t$  data sets presented in Figure 4.0. In a previous investigation (Quirion and Poirier, 2005) we reported preliminary results of the aquaplaning threshold and wet friction on BLANK and HF Cecrisa tiles. At that time, only one data set for each tile was obtained with water and with a detergent solution (sodium lauryl sulphate at 0.15% in water). It was concluded that treating the Cecrisa tiles with HF had little impact on the average roughness and the aquaplaning threshold of the glazed ceramic tiles.

In the present study, the aquaplaning threshold was determined with a slightly different Neolite slider and the results presented in Table 6.0 are the average of four and six independent data sets (see Figure 4.0) obtained with BLANK and HF tiles covered with water. This time however, the aquaplaning threshold of the HF tiles increases from  $16 \pm 4 \mu\text{m}$  to  $26 \pm 4 \mu\text{m}$ . Although this improvement is significant, the values of  $t^*$  remain small. For instance,  $1 \mu\text{m} = 1 \text{ ml/m}^2$  so that  $26 \mu\text{m}$  of water is smaller than half a teaspoon of water spread on a 30 cm x 30 cm tile. Note also that in a previous investigation (Quirion and Poirier, 2006), values of  $t^* = 58 \mu\text{m}$  were obtained for new and sealed quarry tiles ( $Ra = 5.5 \pm 0.2$

$\mu\text{m}$ ) which are not considered as slip resistant tiles. The ABF treatment also increases the value of  $t^*$  (from 16 to 20  $\mu\text{m}$ ) but the improvement is not significant within the experimental uncertainty.

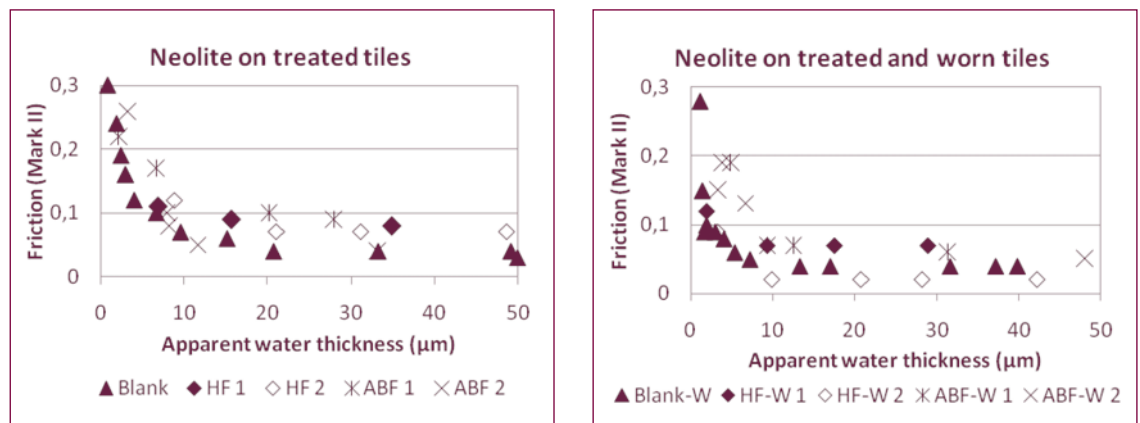
The abrasive wear decreases the aquaplaning threshold of the ABF tiles to a value very close to the worn BLANK tiles, suggesting once again that the submicron particles at the surface of the ABF tiles are easily worn out leaving behind a surface similar to that of the worn BLANK tiles. Abrasive wear also decreases the aquaplaning threshold of the HF tiles. However, the worn HF tiles still have a higher aquaplaning threshold than that of the worn BLANK tiles. These results suggest that the HF treatment acts deeper into the glaze and is more resistant to abrasive wear than the ABF treatment. This observation is in accordance with the gloss results (see Table 4.0).

**Wet friction**

The wet friction coefficient of the Cecrisa tiles was determined using the  $\mu_{wet}$  vs.  $t$  data sets generated with the Falling Plate Method (Figure 4.0) and with the Brungraber Mark II (Figure 5.0). The main difference between the two methods is the much higher load at impact for the Mark II (5 kg) compared to the Falling Plate Method (0.076kg).

For both methods, the wet friction decreases as the apparent water thickness increases until it reaches a plateau at low friction where the risk of aquaplaning is high. A quick comparison of Figures 4.0 and 5.0 indicates that the  $\mu_{wet}$  vs.  $t$  data sets obtained with the Mark II

**Figure 5.0**  
Mark II friction coefficient of Neolite on treated Cecrisa tiles as a function of the apparent water thickness on the tiles



Tile numbers only distinguish independent data sets. Results obtained on the treated tiles (left) are compared with those obtained on the worn tiles (right). Results for the HF and HF-W were obtained with a solution of sodium lauryl sulphate (SLS) at 0.15% in water.

## The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles

	$t^*$ ( $\mu\text{m}$ ) FPM		$\mu_{\text{wet},50}$ FPM		$\mu_{\text{wet},50}$ Mark II	
	Treated	Treated and worn	Treated	Treated and worn	Treated	Treated and worn
BLANK	16 $\pm$ 4	15 $\pm$ 1	0.07 $\pm$ 0.01	0.06 $\pm$ 0.03	0.03	0.04
HF	26 $\pm$ 4	23 $\pm$ 3	0.10 $\pm$ 0.03	0.07 $\pm$ 0.01	(0.07 $\pm$ 0.01) <sup>1</sup>	(0.02 $\pm$ 0.01) <sup>1</sup>
ABF	20 $\pm$ 2	16 $\pm$ 1	0.07 $\pm$ 0.02	0.06 $\pm$ 0.02	0.06 $\pm$ 0.03	0.06 $\pm$ 0.01

**Table 6.0**

Aquaplaning threshold,  $t^*$ , and wet friction at 50  $\mu\text{m}$  of water,  $\mu_{\text{wet},50}$ , of Neolite on Cecrisa tiles after different treatments

Results were obtained with the Falling Plate Method (FPM) and the Brungraber Mark II.

<sup>1</sup> These friction values were obtained with a solution of sodium lauryl sulphate (SLS) at 0.15% in water.

apparatus are shifted to lower apparent water thickness, suggesting that the aquaplaning threshold depends on the load at impact and that it occurs at lower water thickness for higher loads.

These observations indicate that, when comparing wet frictions, it is important to specify the apparent water thickness (amount of water per area of tile) at which the frictions are obtained. Table 6.0 compares the wet friction results at  $t = 50 \mu\text{m}$  (50 ml of water per  $\text{m}^2$ ). At that water thickness, all the tiles tested in this investigation are past the aquaplaning threshold and their wet friction is fairly constant.

The wet frictions at 50  $\mu\text{m}$  obtained with the Falling Plate Method and the Mark II are in fair agreement. Considering that the two experimental methods are completely independent, the overall agreement between the two methods suggests that the Falling Plate Method can provide a fair estimate of the wet friction.

The wet friction obtained with the MARK II for the HF and the ABF treated tiles is essentially the same and slightly higher than that of the BLANK tiles. The Falling Plate Method generates similar results except that the wet

friction of the BLANK tiles is similar to that of the HF and ABF treated tiles. Thus, the Mark II results suggest an improvement of the slip resistance while the Falling Plate Method indicates no changes. But in both cases, the wet friction of the treated tiles remains quite low ( $\mu_{\text{wet},50} < 0.10$ ) so that the improvement remains marginal.

These results do not agree with those of Di Pilla (2000) and Grönqvist *et al.*, (2003) who both observed a drastic increase of the wet friction following chemical treatments. For example, Grönqvist reports an increase of the wet friction from 0.08 to 0.65 after treating a glazed ceramic tile with an ABF solution. The value for the untreated tile is in fair agreement with our results, but the wet friction for the treated tile is much higher than what we observed using the Falling Plate Method and the Mark II. This discrepancy corroborates the difficulty to compare friction results originating from different test methods.

Table 6.0 also indicates that abrasive wear has little impact on the wet friction of the BLANK and the ABF tiles. According to the Falling Plate results, the abrasive wear of the HF tiles has little effect on the wet friction while the Mark II suggests a significant decrease.

EM	Vegetable Oil initial ( $\text{g}/\text{m}^2$ ) <sup>1</sup>	Residual oil on treated tiles (relative to Blank)	Residual oil on treated and worn tiles (relative to Blank)
BLANK	5 and 3	1.00	0.44
HF	6	0.12	0.34
ABF	3	0.14	nd

**Table 7.0**

Ease of maintenance, EM, of Portobello tiles by damp mopping with an anionic degreaser.

<sup>1</sup> The initial amount of vegetable oil on the blank tiles was 5  $\text{g}/\text{m}^2$  for comparison with the HF tiles and 3  $\text{g}/\text{m}^2$  for comparison with the ABF tiles.

### Maintenance of glazed ceramic tiles

Floor cleaning experiments on BLANK, HF and ABF tiles were performed in order to determine how the HF and ABF treatments affect the ease of maintenance of glazed ceramic tiles. The cleaning tests were conducted on Portobello tiles covered with vegetable oil and cleaned using damp mopping with an anionic degreaser. The results are reported in Table 7.0.

In this investigation, the ease of maintenance, *EM*, increases from 0 to 1 with one being the ease of maintenance of a BLANK tile. The first observation is that all values of *EM* are smaller than one, suggesting that the unworn BLANK tiles, used as the reference tiles, were the easiest to clean.

The HF and ABF treatments drastically reduce the value of *EM* to 0.12 and 0.14, respectively. In other words, the same cleaning procedure leaves around eight times more oil on the treated tiles relative to the unworn BLANK tiles. As the HF treatment wears out, the ease of maintenance re-increases but only to a value similar to the worn BLANK tiles. In other words, abrasive wear makes the glazed ceramic tiles more difficult to clean but that effect is less pronounced than the decrease of *EM* following the HF and ABF treatments.

Hupa *et al.*, (2005) also noted that once a smooth glaze is corroded, it becomes more difficult to clean. In the case of HF and ABF tiles, the decrease of *EM* is probably due to the entrapment of oil into the holes left by the HF treatment or within the layer of submicron particles left by the ABF treatment at the surface of the glaze. So, in order to properly remove the trapped oil, the treated floors have to be cleaned with a more aggressive procedure. Because of the fragility of the HF treated glaze and the small adherence of the submicron particle layer left by the ABF treatment, making floor cleaning more aggressive should also result in a faster deterioration of the glaze treated with HF and a faster disappearance of the submicron particles deposited through the ABF treatment.

### Discussion

This investigation deals with the impact of chemical treatments based on aqueous solutions of hydrofluoric acid, HF, or ammonium bifluoride, ABF, on various properties of glazed ceramic tiles. The impact of these surface changes on the properties of the glazed ceramic tiles is discussed for each treatment separately.

### Chemical treatments based on hydrofluoric acid

The HF treatment solubilises part of the glaze and leaves micrometer holes at the surface of the glaze. The chemical composition of the treated glaze does not change but the presence of the holes makes it more fragile and more difficult to clean. Hence, daily traffic and routine floor maintenance should degrade the glaze of HF tiles at a faster rate than the untreated tiles. The holes are fairly deep so that the glaze does not completely recover its gloss as the treatment wears out.

The HF treatment increases only slightly the average roughness and dry friction of the glazed tiles. The treated tiles have a higher resistance to aquaplaning than the untreated tiles but the magnitude of the effect remains relatively small. When the amount of water on the tile is over the aquaplaning threshold, the wet friction of the HF tiles is a little higher than that of the untreated tiles but still quite low ( $\mu_{wet} \sim 0.1$ ). Finally, the slight increase of the average roughness, dry and wet frictions and aquaplaning threshold disappears as the treated tiles wear out.

### Chemical treatments based on ammonium bifluoride

The submicron particles deposited on the glazed tiles during the ABF treatment are rich in fluorine and they do not adhere very strongly to the glaze. The treated tiles are more difficult to clean, probably because oils and fats can be trapped into the layer of submicron particles. To counteract that effect, more aggressive floor cleaning methods and detergents are needed, thus accelerating the maintenance wear of the ABF tiles.

The ABF treatment does not increase significantly the average roughness and the dry friction and it slightly increases the resistance to aquaplaning. However, the wet friction remains quite low.

The elimination of the layer of submicron particles exposes a glazed surface very similar to that of the BLANK tiles. Thus, one can expect that the tiles will recover their surface properties as the ABF treatment wears out.

### General discussion

Most manufacturers of chemical treatments require that the floor is properly cleaned with a degreaser before the application of the treatment. Interestingly, it was demonstrated (Quirion *et al.*, 2007) that improving the floor cleaning procedure often results in the

# The impact of chemical treatments on the wear, gloss, roughness, maintenance and slipperiness of glazed ceramic tiles

improvement of the slip resistance. Thus, trying to improve the floor cleaning procedure should always be the first step. And if that does not improve the slip resistance of the floor, then one could think of applying a chemical treatment.

The ABF treatment is less aggressive because it does not alter significantly the glaze. However, its impact on the slip resistance is marginal and it wears out rapidly. That observation is in accordance with the frequent usage recommended by the manufacturers. In that sense, the ABF solutions resemble more to cleaning solutions than to chemical treatments.

That is not the case for the HF treatments. First, the products contain HF, which is a hazardous chemical that should be used with caution. The improvement of the slip resistance is better than that observed with ABF but it remains fairly small and it disappears as the treated tiles wear out.

Because of its negative impact on the resistance to wear and ease of maintenance and its rather small impact on the slip resistance, treating glazed ceramic tiles with HF solutions should be considered as a short term option for old and worn ceramic floorings that have to be replaced anyway.

It is important to stress that the above observations are based on the results obtained using the experimental procedures and the glazed tiles described in this article. It is possible that changes in the application procedure of the chemical treatments or the use of different glazed tiles would lead to different results.

## Conclusions

This investigation deals with the impact of one chemical treatment based on an aqueous solution of hydrofluoric acid, HF, or ammonium bifluoride, ABF, on various properties of glazed ceramic tiles.

### The HF treatment:

- solubilises part of the glaze resulting in micrometric holes at the surface but has little impact on the average roughness of the tiles,
- does not affect significantly the chemical composition of glaze,
- reduces significantly the gloss of the glaze,
- makes the glaze more fragile so that it becomes more sensitive to abrasive and maintenance wear,
- makes the tiles more difficult to clean,

- increases slightly the aquaplaning threshold and the wet friction.

### The ABF treatment:

- leaves a layer of submicron particles rich in fluorine that is easily removed from the surface of the glaze by abrasive wear,
- reduces significantly the gloss of the glaze but the gloss increases again as the layer of submicron particles wears out,
- has little impact on the average roughness of the tiles,
- does not seem to make the remaining glaze more fragile,
- makes the tiles more difficult to clean,
- has little impact on the aquaplaning threshold and the wet friction.

Overall, the slight increase in slip resistance observed after one treatment with an HF solution is not worth the deterioration of the glaze that makes it more fragile and more difficult to clean. These treatments should be applied only as a temporary solution on old glazed tiles. The ABF treatments seem to have little impact on the slip resistance and the sensitivity to wear of the glaze ceramic tiles.

The results obtained are for a given application procedure of the treatments on given glazed ceramic tiles. Different results leading to different conclusions could probably be observed with different application procedures and different tiles.

## Acknowledgements

This investigation was supported by the *Institut de Recherche Robert-Sauvé en santé et en sécurité au travail* under grant 099-179.

## References

- Bowman R, Strautins C J, Westgate P and Quick G W** (2002). Implications for the development of slip-resistance standards arising from rank comparisons of friction-test results obtained using different walkway-safety tribometers under various conditions. In ASTM STP 1424, Metrology of pedestrian locomotion and slip resistance, 112-136.
- Chang W R, Kim I J, Manning D P and Bunternghit Y** (2001). The role of surface roughness in the measurement of slipperiness. *Ergonomics*, 44(13), 1200-1216.



**Chang W R, Hirvonen M and Grönqvist R** (2004). The effect of cut-off length on surface roughness parameters and their correlation with transition friction. *Safety Science*, 42, 755-769.

**Cholet C, Salimbeni E and Vetter F** (2000). Glissance des revêtements de sol: Étude expérimentale. Cahier du CSTB No. 3234, Livraison 411.

**Di Pilla S** (2000). Slip resistance treatment: Study 2000, ESIS risk control services, Report available online at URL: [www.esis.com/InTheNews/ESISSRT2000-0600.pdf](http://www.esis.com/InTheNews/ESISSRT2000-0600.pdf) [Accessed 18/07/09].

**Fang Q, Sidky P S and Hocking M G** (1997). The effect of corrosion and erosion on ceramic materials. *Corrosion Science* 39, 511-527.

**Grönqvist R, Hirvonen M and Skyttä E** (1992). Countermeasures against floor slipperiness in the food industry. In *Advances in Industrial Ergonomics and Safety IV*, S. Kumar (ed), Taylor and Francis, 989-996.

**Grönqvist R, Matz S and Hirvonen M** (2003). Dynamic friction in the shoe-floor interface with respect to floor surface roughness and contamination. In *Proceedings of the XV Congress of the International Ergonomics Association*, Seoul Korea.

**Hupa L, Bergman R, Fröberg L, Vane-Tempest S, Hupa M, Kronberg, Pesonen Leinonen, E, Sjöberg, A M** (2005). Chemical resistance and cleanliness of glazed surfaces. *Surface Science*, 584, 113-118.

**Lee J C, Song H J, Park M J and Shin H I** (2001). Pore development in alumino-silicate fibres treated in hydrofluoric acid solutions, *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 187-188, 399-403.

**Lemon P and Worth J** (2008). Assessing slipperiness: How inspectors do it! *Contract Flooring Journal* (CFJ), July 2008, 32.

**Loo-Morrey M** (2007). A study of the slip characteristics of natural and manmade stone flooring materials, Health and Safety Executive, HSE Research Report RR529.

**Loo-Morrey M** (2006). Ramp testing natural and man made stone floors – Final Report, Health and Safety laboratory, HSL Report No HSL/2006/47.

**Luo X P, Silikas N, Allaf M, Wilson N H F and Watts D C** (2001). AFM and SEM study of the effects of etching on IPS-Empress 2TM dental ceramic. *Surface Science*, 491, 388-394.

**Quirion F** (2004). Optimal cleaning for safer floors, *Contemporary Ergonomics 2004*, CRC Press, Ed. Paul T. McCabe, p : 28-32. For a detailed description of the cleaning methods used in our laboratory please consult the following report: Massicotte A, Boudrias S and Quirion F (2000) Conditions optimales d'utilisation des nettoyeurs à planchers : une approche globale, Rapport de recherche de l'IRSST No R-258. Available online at [www.irsst.qc.ca/fr/\\_publicationirsst\\_783.html](http://www.irsst.qc.ca/fr/_publicationirsst_783.html) [Accessed 18/07/9].

**Quirion F and Poirier P** (2005). The impact of heel material, Detergent and Acid Etch on the Risk of Slipping and Sliding on Wet Floorings. In *Proceedings of the XIX Annual ISOES Conference in Las Vegas*, Lockhart T R S and Fernandez J E (Eds), 501-507.

**Quirion F and Poirier P** (2006). Aquaplaning threshold and wet friction of various floorings. *Proceedings IEA2006 Congress*, Eds. Pikaar R N, Koningseld E A P and Settels P J M, Elsevier Ltd.

**Quirion F and Poirier P** (2007). The Falling Plate Method: Evaluating the risk of aquaplaning on wet floor. *Journal of Environmental Health Research*. 6(2), 71-80.

**Quirion F, Poirier P and Lehane P** (2007). Optimal cleaning to prevent slippery floors in restaurants. *Journal of Environmental Health Research*, 6(1), 25-33.

**Rabinowicz E** (1995). *Friction and Wear of Materials*. 2nd edition, John Wiley & Sons.

# Risk factors in children's accidents leading to emergency treatment in hospital

Triantafillia T Glania<sup>1</sup>, Theodoros Lialiaris<sup>2</sup>, Grigorios Tripsianis<sup>3</sup> and Theodoros C Constandinidis<sup>4</sup>

<sup>1</sup> Physical Education Teacher, MSc Physical Education and Sports Science, PhD student in Medical School, Democritus University of Thrace, Alexandroupolis, Greece

<sup>2</sup> Medical School, Democritus University of Thrace, Alexandroupolis, Greece.

<sup>3</sup> Laboratory of Statistics, Medical School, Democritus University of Thrace, Alexandroupolis, Greece.

<sup>4</sup> Laboratory of Hygiene and Environmental Protection, Medical School, Democritus University of Thrace, Alexandroupolis, Greece.

**Correspondence:** Glania Triantafillia, Irakleitou 7, Alexandroupolis, 68100, Greece.  
Telephone: 00306974072979. E-mail: filgla@yahoo.com

## Abstract

This research aimed to study children's accidents and compare sexes' accidents in a northern part of Greece, Thrace. Specifically, it examined whether there was a correlation between each risk factor that was used in the research, and the dependent variables: 1. minor accidents, 2. serious accidents that required Emergency Room attendance (ER accidents), 3. serious accidents that lead to hospital admission (admission accidents). 1,516 high school children completed an anonymous questionnaire regarding the cause, the activity before the accident, the place, and result of their accident.

The results indicated that sex, grade, mother's studies, father's studies and nationality were important risk factors for minor injuries. It appears that young boys (7th grade), immigrants and the children whose parents received higher education were at greater risk of having minor injuries. Sex (girls had OR: .5; CI .4-.63) and nationality (immigrants had OR: 2.75; CI 1.82-4.16) continued to be important risk factors for E.R. accidents. Only sex was an important risk factor in admission accidents. Girls had OR .436 (CI .245-.774,  $p=.004$ ). Sex and nationality were found important for ER accidents but only sex was important for admission accidents.

Although many surveys examine risk factors and accidents, this has gone a little further examining risk factors that account for serious injuries which lead to an E.R. or a hospital admission. As major accidents may result in serious health problems or even disability, attention should be paid to the risk factors found.

**Key words:** Accident; children; environmental health; emergency room; hospital admission; injury; safety.

## Introduction

Annually, more than 790,000 people die of unintentional injuries in Europe (Petridou, *et al.*, 2005), which represents 15% of all deaths from injuries worldwide. Studies show that the mortality rate in Europe is about 90 deaths per 100,000 residents, while in the U.S.A. the corresponding number is 53 per 100,000 (Roberts, 2005). Non fatal injuries account for a big public health problem; it is estimated that more than 15 million injuries in Europe need medical care in a hospital, while about 6 million years of life are lost because of post-traumatic disability (Centre for Research and Prevention of Injuries, 2005). Although the EU is described as one of the safest regions in the world, much

space for improvement concerning accidents still exists. Since May 2004, when the EU consisted of 15 members, the Standard Death Rate (SDR) from injuries was roughly 39 deaths per 100,000, while after the integration of 10 new countries, it went up considerably to 45 deaths per 100,000 (Ministry of Health and Social Solidarity, 2008). More specifically, statistics about children show that Sweden, the United Kingdom, Italy and the Netherlands are at the top of a table with the least children's deaths from injuries. Sweden has a low annual number of deaths from injuries (intentional and unintentional): 5.2/100,000 children, for ages of 1-14 years and during the period 1991-1995 (Ekman, *et al.*, 2005). Most children's fatal injuries were recorded in Portugal, which had a double rate compared to the pre-mentioned countries (Unicef, 2001).

Injuries are the main cause of death in children (0-14 yrs-old), adolescents and young persons (15 until 24 years) (Centre for Research and Prevention of Injuries, 2005; EU Council, 2007; European Union Council, 2006; Ministry of Health and Social Solidarity, 2008). Fortunately, fatal injuries in the EU-25 present a downturn. From 1994 till 2003, the SDR for all kinds of injuries were reduced from 53 to 43 deaths per 100,000 residents (European Association for Injury Prevention and Safety Promotion, 2006).

The main causes of lethal accidents for the 29 countries – members of the Organisation for Economic Co-operation and Development (OECD), for ages of 1-14 years old during 1991-1995, were: 41% accidents on the street (pedestrian, cyclist, passenger), 15% drownings, 14% intentionally caused, 7% fire accidents, 4% falls, 2% poisonings, 1% gun accidents, and 16% other accidents (Unicef, 2001).

Accidents are connected to various types of activity and take place at different settings, as in the house, at school and in the street (NHS, Quality Improvement Scotland, 2004). The place where children had accidents most often was their school (inside or in the yard), where almost 1/3 of all children had suffered an accident. It is remarkable that more than 1/3 of young men (15-24 years old) were injured in an athletic centre (or gymnasium), while the respective injuries of young women were far lower (Hellenic Ministry of Health and Welfare, 2003). In Canada, 38% of 5-9 year-old children had domestic accidents while older children (10-14 years old) had a lower percentage for domestic accidents (23%). The latter had injuries during their playing outside (15%) and on the street (15%) (Health Canada, 1999).

### Injury intensifiers

It was calculated that one third of accidents can be anticipated under the existing standards of prevention (Chang, *et al.*, 2004; Dessypris, *et al.*, 2002). Risky behaviour was found to predict in an important degree consequent injuries (Bijttebier, *et al.*, 2003). The difficult work appears to be the adoption of these preventive measures diminishing risky behaviour. Boys are often involved in risky behaviours (Health Canada, 1999). In a research study in Finland, boys had a slightly higher percentage of injuries compared to girls (odds ratio, OR: 1,33; 95% CI) (Mattila, *et al.*, 2004).

Most researchers agree that male sex, early adolescence, minority groups and low social economic status are the predominant risk factors for children's accidents (Haynes, *et al.*, 2003; Otters, *et al.*, 2005; Unicef, 2001). Boys generally face more and more severe accidents (NHS, Quality Improvement Scotland, 2004; North Carolina Institute of Medicine, 2000). Nationality and family income were recognized as important risk factors (Chen, *et al.*, 2005; Karr, *et al.*, 2005). In a review of 57 different studies that examined the relation of socio-economic level (Social Economic Status-SES) and accidents, it was found that accidents are related to SES (MacKay, *et al.*, 1999).

Injuries affect disproportionately the most vulnerable children and adolescents (Unicef, 2001). Moreover, the continuous loss of children and adolescents because of injuries is a critical demographic and economic issue (European Child Safety Alliance, 2009). Family reasons are intensifiers (e.g. low income, overcrowding, low level of parents' education, young mother, a family with many children) (Reading, *et al.*, 1999). Although some agree that a risk factor is the low level of education the parents have, it was found that parental levels of education had no effect in falls for boys but increased the risk of falls for girls (Faelker, *et al.*, 2000). Environmental reasons can escalate the number of deaths from injuries, (e.g. traffic/ too many vehicles, unfavourable living conditions, direct access of houses in busy streets of dense circulation, inadequate supervision of children) (Reimers & Laflamme, 2005).

Minority children that live in poor neighborhoods have to face a more dangerous environment around them. Children from many-membered families or working children are at greater risk of accidents than their age-mates (Bartlett, 2002). This can be explained since these children live in stifling neighborhoods, with no safe playing areas or safe places of recreation (MacKay, *et al.*, 1999).

Nationality (not western children OR=.67, 95% CI) and low socio-economic level (OR=1.39; 95% CI) were also related to accidents in 12-17 year-olds in Denmark (Otters, *et al.*, 2005). In the same research, it appeared there was an increased danger of injuries for younger children (0-4 years) with many siblings (> or = 3 siblings, OR=1,57; CI =95%). Minorities usually have bigger rates of mortality because of the increased levels of poverty and low levels of education, low employment and income (Ministry of Health and Social Solidarity, 2008). While poverty was more generally a risk factor for unintentional accidents in a research study in Vietnam, it appeared to act protectively for accidents in school and it did not increase the odds ratio for street accidents (Thanh, *et al.*, 2005). Similarly, in a study in Stockholm, the low socio-economic status of families had a protective effect for 10-19 year-old boys in traffic and athletic accidents (Faelker, *et al.*, 2000) but was a risk factor for falls. Additionally, the levels of education and the economic resources of each family did not have an effect on falls for boys but increased the danger of falls for girls. In Sweden, the research of Engstrom, *et al.*, (2002) showed that accidents were not related with the socio-economic differences for 0-4 yr olds.

Children of small provincial areas faced a bigger risk of accidents or deaths (National SAFE KIDS Campaign - NSKC, 2004; Washington State Department of Health Maternal and Child Health Assessment, 2006). On the contrary, some other researchers reached contradicting results. People living in cities faced a higher risk than people living in rural areas in Tanzania (Moshiro, 2005). Similarly, living in urban areas was found to be a powerful risk factor for accidents in all ages (0-17) (Otters, *et al.*, 2005). Other risk factors were the family background of illnesses or insufficient supervision during the children's playing, which at least doubled the danger (Wazana, 1997).

Indeed, accidents are the main cause of children's death all over the world, even if an important percentage of these deaths can both be foreseen and predicted (Department of Hygiene and Epidemiology, 2004). In a study by the Greek Ministry of Health about the Greek population, more than 19% of the accidents were related to children from 10 to 19, 14% to 5-9 year-old children and 16% were the accidents for younger children (0-4 y.). A great percentage of accidents were related to children in their teens, which is worryingly high for the total population (Hellenic Ministry of Health and Welfare, 2003). In Greece, the distribution of deaths per type of accident, age-related group and sex were as follows: the main cause of accidents for 5-9 year olds were traffic-related accidents; similar were the results for

## Risk factors in children's accidents leading to emergency treatment in hospital

10-14 yr-olds. Boys had more accidents (60%) in both age groups (Ministry of Health and Social Solidarity, 2008). Generally most injuries and most serious ones are traffic related for children in their teens.

### Purpose

The purpose of this research was to study children's accidents and find out their causes in the region of Thrace, Greece. Specifically, whether there was a correlation between each risk factor that was used in the research, and the dependent variables: 1. minor accidents, 2. serious accidents that required emergency room attendance (ER accidents), 3. serious accidents that lead to hospital admission (admission accidents). Moreover, another purpose was to compare the accidents of sexes in the area.

### Method

1,516 high school children (52% boys, 48% girls) from 11 schools in Thrace completed an anonymous questionnaire. Before it was handed out to children, the Greek Ministry of Education gave the permit for the researchers to get into schools and carry on with it. Moreover, each parent gave their written consent that they allowed their child to participate in the study. The children's rights were fully protected at each step of the research. The questionnaire was created by the research team. Some of the questions had to do with the children's demographic information (e.g. "Do you live in a city?" or "Do you live with both your parents?") and they had to circle the answer that was correct for them. Some other questions asked them to answer directly (e.g. "How many times have you been to the ER during the last six months?"). Then, children who had an accident during the specific period of time were asked to describe the most serious one, which led them to the ER or to admission. After all the necessary instructions, they were advised to give information about the cause of the accident, the exact activity the children participated just before the accident occurred, the place it happened and finally the result of their accident. All children were advised to answer truthfully and they were given all the clarifications needed. The process took about 45 min. for each class and then children handed the questionnaires back. All the information was coded for data entry and analysed using SPSS (version 10). Descriptive statistics of the sexes were obtained, chi-square statistics and odds ratio (OR) were calculated between independent variables (age, sex, etc.) and the dependent ones (minor accidents, ER admission).

## Results

### Descriptives of boys

Some descriptive statistics concerning the cause of the accident, the activity they engaged in at the time of the accident, the place of the accident and the result of it, are presented in Table 1.0. The major causes of accidents for boys was accidents on a bike /motorbike, falls as they were walking or running, and various sport-related accidents. Just before the accident occurred, most boys stated that they were freely playing with no adult's supervision (parent or teacher) while one out of four young men was riding a motorbike or bicycle at the time of the accident. A relatively large percentage of boys were injured in an organised athletic activity, either at school (physical education class, school matches etc.), or at organised sport clubs under the supervision of their coach/physical education teacher. Most boys' accidents happened on the street, while a great percentage of them took place in an athletic centre (gymnasium) or at their school. After the accident, the majority of boys were looked after by a teacher or a relative, while four out of 10 were brought to a hospital ER either for treatment or countercheck. The percentage of boys that needed admission in a hospital was twice the girls' percentage.

### Descriptives for girls

Girls had high numbers of accidents for falls, sport-related accidents, cuts/piercing with sharp objects and burns/scalds. Worrying was the high percentage of girls (more than one out of three) that stated they did nothing in particular at the time the accident occurred (slicing bread or going down the stairs etc.), as about one out of five was injured during their unsupervised playtime. Besides that, about one girl out of seven was injured, under the supervision of their coach/physical education teacher, during an organised athletic activity at school or at an organised sport clubs. Girls were mostly injured at home, although a relatively large percentage of them were injured on the street or at school. The great majority of girls received first aid for their injuries from a teacher or a relative, while many fewer girls than boys needed to be taken to a hospital for treatment, or to have been admitted.

### Injuries in general, minor ones

It appeared that the relative danger of injury generally for non-native children is increased. Thus, the odds ratio (OR) for non-native children (immigrants) is more than

**Table 1.0**  
Descriptive  
statistics of the  
accidents for both  
sexes

	Boys %	Girls %
<b>Cause</b>		
1. Bike/motorbike	23.6	9.1
2. Falls	19.3	23.8
3. Sport-related	18.4	17.9
4. Cuts/piercing	12.1	12.2
5. Burns/scalds	3.4	11.8
<b>Activity before the accident</b>		
1. Unsupervised playing	32.3	19.8
2. Riding (motorbike/bicycle)	24.9	11.2
3. Organised/Supervised athletic activity	17.5	14.7
4. Nothing in particular	13.6	38.3
<b>Place</b>		
1. Street	28.9	17.1
2. Athletic centres	20.7	10.3
3. School	12.6	15.4
4. Home	9.3	30.7
<b>Accident result</b>		
1. Teacher/relative	31.6	44.8
2. ER treatment	22.3	18.7
3. ER and countercheck	18.2	12.2
4. Hospital admission	6.9	3.6

three times compared to the natives in Thrace. Children, whose parents had received higher education, also appeared to have higher odds. Grade appeared to be connected with the existence of accidents and more specifically, children in 7th grade had more odds to be injured compared to the next two grades.

Sex, as expected, had a high correlation to accidents. Thus, girls had about half odds compared to boys. No other variable (living in a city or village, living with one or both parents, being an only child or not) was found to be statistically important for minor children injuries ( $p < .05$ ). All the necessary information is shown in Table 2.0.

#### **Serious injuries-transport to ER or hospital admission**

Fewer variables were connected and seemed important when talking about serious accidents that resulted in a hospital ER or in admission. The probability of a child being brought into the ER of a hospital in combination with all the variables was examined and is presented in Table 3.0. Immigrants continued to have higher probability ( $OR=2.7$ ) to be taken to a hospital ER compared to natives. So, nationality seems to be important. Another important variable was sex. It seemed that girls presented half the probability of being transferred to a hospital E.R. It should

Risk factors in children’s accidents leading to emergency treatment in hospital

Variable	%	OR	95%CI	P
Natives	70.4	1.000	(ref.)	
Immigrants	88.8	3.328	1.760-6.296	.000
Highly educated mother	76.3	2.516	1.960-3.230	.000
Mother’s basic/ intermediate education	56.1	1.000	(ref.)	
Highly educated father	74.7	2.148	1.640-2.813	.000
Father’s basic/ intermediate education	57.9	1.000	(ref.)	
Boys	77.4	1.000	(ref.)	
Girls	65.2	.548	.437-.687	.000
8th & 9th grade	69.4	1.000	(ref.)	
7th grade	76.2	1.412	1.103-1.806	.006

**Table 2.0**  
Minor accidents and the relative danger (OR) in relation to the following variables.

also be mentioned that a tendency appeared for children with siblings. They appeared to have less possibility (.7) of being brought to an ER, even though ‘p’ was not statistically important but close enough (p=.067).

Finally, the probability of a child being admitted to a hospital in combination to all the variables was examined but only sex appeared to be connected. No other variable appeared to be statistically important. Boys continued being in greater danger of being admitted in a hospital, and more specifically their relative danger was twice the danger girls had, as girls had odds ratio .436 (C.I. =.245-.774, p=.004).

**Discussion**

**Sex**

As it was expected from literature, there were certain variables that could worsen the fact that children might have an accident. It is already well documented that sex is an intensifier (NHS, Quality Improvement Scotland, 2004; North Carolina Institute of Medicine, 2000; Unicef, 2001). The present research also confirms that boys are in greater danger of accidents than girls. Moreover sex was the only variable that was connected to all three dependent variables we examined. It was an intensifier for accidents in general, ER accidents and accidents resulting in admission. Girls had half the odds for an accident (serious or minor)

compared to boys, having all the other variables the same (Haynes, *et al.*, 2003; Otters, *et al.*, 2005). So it is of great importance to talk to boys and try to protect them by showing all the dangers around them. They were mostly injured on motorcycles/bicycles, mainly because they didn’t wear helmets. It would be interesting to mention first, that legislation in Greece obliges motorcyclists to wear a helmet but most of the times they don’t, and next, that there is no law to oblige pedal cyclists to wear one. This is worrying if we consider that the majority of accidents boys had, could have been prevented if all children realised the danger and wore helmets. Recently, a preventive approach towards accidents was developed. It includes the “3 Es” from the words Education/behaviour, Engineering/technology, Enforcement/legislation. It has been documented that the technology approach is more effective than legislation and that education is the least effective. Modifying the environment where people work, live or play – through technology or public policy – appears to be the most effective way for injury reduction. Education – a well informed public – plays an important role in this objective, specifically when it is accompanied by technology and legislation (Alaska Adolescent Health Advisory Committee, 1997). In interventionist research at schools, communities and municipalities, it was found that education was effective in the use of bicycle helmets or seat belts but didn’t help in the reduction of adolescents’ risky behaviour, or driving and alcoholism (Klassen, *et al.*, 2000). In any case, programmes for the reduction of

**Table 3.0**  
ER accidents and  
the relative danger  
(OR) in relation to  
the following  
variables

Variable	%	OR	95%CI	P
Living in a village	31.2	1.000	(ref.)	
Living in a city	28.6	0.882	.708-1.099	.264
Living with one parent	32.9	1.000	(ref.)	
Living with both parents	29.4	0.849	.604-1.193	.344
Natives	28.3	1.000	(ref.)	
Immigrants	52	2.752	1.821-4.158	.000
Highly educated mother	30	1.041	0.801-1.352	.765
Mother's basic/ intermediate education	29.2	1.000	(ref.)	
Highly educated father	30.4	1.174	.878-1.568	.279
Father's basic/ intermediate education	27.1	1.000	(ref.)	
Boys	36.5	1.000	(ref.)	
Girls	22.5	.505	.403-.633	.000
An only child	35.3	1.000	(ref.)	
Had siblings	29	.747	.546-1.021	.067
8th & 9th grade	29.2	1.000	(ref.)	
7th grade	31.2	1.099	.87-1.388	.428

injuries should include changes in the behaviour of the particular crowd of the region it is aimed at, so that they cover the existing needs and resolve the particular problems of residents in that area.

#### Immigrants

Another risk factor was nationality. Non-natives were in greater danger both for minor and ER accidents. It was shown that immigrants had OR about three times compared to natives. It may be the many hours their parents were working to improve their life and/or the riskier kind of life those children were leading (as most of the time their parents weren't home), that brought about so many accidents. Minorities are really in greater danger of suffering from an accident as most literature

suggests (Bartlett, 2002; MacKay, *et al.*, 1999) although in another research there were some opposite results since it was shown that minorities were less prone than western children (Otters *et al.*, 2005).

#### Living in a family with many children/ living with one parent

Living with one parent or in a many membered family were not intensifiers. It was not established that many children in a family may be a risk factor as literature showed (Otters, *et al.*, 2005; Wazana, 1997), although there seemed to be a tendency for children with siblings to have fewer ER accidents. This could be explained by the fact that older children in Greece are used to taking care of or babysitting their younger siblings, and most of the time



## Risk factors in children's accidents leading to emergency treatment in hospital

are great at it. Consequently, efficient supervision of their young siblings may result in fewer accidents. Moreover, someone would assume that when one parent lives with the child, they are forced to work more and thus pay less attention to their child. This assumption was not established, though. It seems that, before the parent leaves home, they have already made arrangements for the good care of their children (supervised by nannies, grandparents or siblings) to make sure they will be safe. Grade was also connected to minor accidents but not serious ones (ER accidents or admissions).

#### Parents' educational level

Although the literature showed that parents with low levels of education had children with more accidents (Faelker, *et al.*, 2000), it was the opposite that this study found. It seems that when both parents have higher levels of education, their children are in greater danger of having a minor accident. That could be because the majority of people in Greece study one thing, but work in another. Highly educated and thus well paid jobs are few. As a result, the job they usually find is inferior to their studies and as a consequence they have to work more hours in environments that are lower than they deserve according to the studies. Sometimes they have to work straight from one job to another to make their living. That results in many hours of absence from home, leaving children alone.

#### Place where children live

There was no correlation between the place children lived and their having accidents. Although some researchers found that children in urban areas suffer most from accidents (Moshiro, 2005; Otters, *et al.*, 2005), some others claimed the opposite (National SAFE KIDS Campaign – NSKC, 2004). This study, though, found no link between the place children lived and the injuries they had.

## Conclusions

It appears that:

- Young boys (7th grade), immigrants and the children whose parents received higher education were at greater risk of having minor injuries
- Boys are in greater danger of both minor and major accidents (ER accidents or admissions)
- Minorities – immigrants – suffered more injuries, both minor and major
- Apart from the above, no other variable was

statistically important for major accidents, so no other risk factor was found for ER accidents or accidents resulting in hospital admissions.

Although many surveys examine risk factors and accidents, this has gone a little further in examining risk factors that account for serious injuries which lead to an E.R. or a hospital admission. As major accidents may result in serious health problems or even disability, attention should be paid to the risk factors connected to those serious accidents.

## References

**Alaska Adolescent Health Advisory Committee (AHAC)** (1997). Unintentional Injury Among Adolescents. Adolescent Health Research Updates. Suppl. to the Adolescent Health Plan, 2, 1- 8.

**Bartlett S N** (2002). The problem of children's injuries in low income countries: a review. *Health Policy and Planning*, 17(1), 1-13.

**Bijttebier P, Vertommen H and Florentie K** (2003). Risk-taking behaviour as a mediator of the relationship between children's temperament and injury liability. *Psychol Health*, 18(5), 645 – 653

**Centre for Research and Prevention of Injuries (CEREPRI)** (2005) Burden of fatal injuries in the European Union: Report of the Task Force on Burden of Injuries. Working Party on Injuries and Accident, Athens.

**Chang J T, Morton S C, Rubenstein L Z, Mojica W A, Maglione M, Suttorp M J, Roth E A & Shekelle R G** (2004). Interventions for the prevention of falls in older adults: Systematic review and meta-analysis of randomised clinical trials. *BMJ*, 328, 680-683.

**Chen G, Smith G, Deng S, Hostetler S & Xiang H** (2005). Nonfatal injuries among middle-school and high-school students in Guangxi, China. *American Journal of Public Health*, 95(11), 1989-95.

**Department of Hygiene and Epidemiology** (2004). Brief report of CEREPRI activities, University of Athens.

**Dessypris N, Petridou E, Skalkidis Y, Moustaki M, Koutselinis A & Trichopoulos D** (2002). Countrywide estimation of the burden of injuries in Greece: a limited resources approach. *J Cancer Epidemiol Prevention*, 7, 123-129.

Triantafyllia T Glania, Theodoros Lialiaris, Grigorios Tripsianis  
and Theodoros C Constandinidis

**Ekman R, Svanstrom L & Langberg B** (2005). Temporal trends, gender, and geographic distributions in child and youth injury rates in Sweden. *Injury Prevention*, 11(1), 29-32.

**Engstrom K, Diderichsen F & Laflamme L** (2002). Socioeconomic differences in injury risks in childhood and adolescence: a nation-wide study of intentional and unintentional injuries in Sweden. *Injury Prevention*, 8(2), 137-42.

**EU Council** (2007). Constitution of council on 31 May 2007 regarding to the prevention of injuries and the promotion of safety. Official Newspaper of the European Union, 50 (C164/01).

**European Association for Injury Prevention and Safety Promotion** (2006). Injuries in the European Union: Statistics summary 2002-2004. Vienna. Available at: EUROSAFE [http://ec.europa.eu/health/ph\\_determinants/environment/IPP/documents/InjuriesEU\\_sum\\_en.pdf](http://ec.europa.eu/health/ph_determinants/environment/IPP/documents/InjuriesEU_sum_en.pdf) [accessed 10/08/09]

**European Union Council** (2006). Proposal for a council recommendation on the prevention of injury and the promotion of safety. Commission of the European Communities. Brussels, 329.

**Faelker T, Pickett W and Brison R** (2000). Socio-economic differences in childhood injury: a population-based epidemiologic study in Ontario, Canada. *Injury prevention*, 6(3), 203-8.

**Haynes R, Reading R & Gale S** (2003) Household and neighbourhood risks for injury to 5-14 year old children. *Social science and medicine*, 57(4), 625-36.

**Health Canada** (1999). Healthy Development of children and youth, Ottawa, Ontario

**Hellenic Ministry of Health and Welfare** (2003). Annual European Home and Leisure Accident Surveillance Report, Centre for Research and Prevention of Injuries among the young, CEREPRI, Greece.

**Karr C, Rivara F and Cummings P** (2005). Severe injury among Hispanic and non-Hispanic white children in Washington state. *Public health reports*, 120(1), 19-24.

**Klassen T P, MacKay J M, Moher D, Walker A and Jones A L** (2000). Community-based injury prevention interventions. *Future Child*, 10(1), 83-110

**MacKay M, Reid D C, Moher D and Klassen T** (1999). Systematic review of the relationship between childhood injury and socio-economic status. Published by authority of the Minister of Health (from: [www.hc-sc.gc.ca/hppb/childhood-youth](http://www.hc-sc.gc.ca/hppb/childhood-youth)).

**Mattila V, Parkkari J, Kannus P and Impela A** (2004). Occurrence and risk factors of unintentional injuries among 12 to 18-year-old Finns – a survey of 8,219 adolescents. *European Journal of epidemiology*, 19(5), 437-44.

**Ministry of Health and Social Solidarity** (2008). National action plan for Public Health: National action plan for accidents, 2008-2012. Athens.

**Moshiro C** (2005). The epidemiology of injuries in an urban and two rural areas of Tanzania: a population-based study, Philosophiae Doctor (PhD) Thesis, Centre for International Health University of Bergen, Norway.

**National SAFE KIDS Campaign** (NSKC) (2004). Children at Risk Fact Sheet, Washington (DC): NSKC.

**NHS, Quality Improvement Scotland** (2004). Health Indicators Report: A focus on children, Scotland. Available online at: [www.nhshealthquality.org/nhsqis/files/2004%20Health%20Indicators%20Report.pdf](http://www.nhshealthquality.org/nhsqis/files/2004%20Health%20Indicators%20Report.pdf) [accessed 10/08/09].

**North Carolina Institute of Medicine** (2000). Comprehensive Child Health Plan: 2000-2005, Task Force Report to the North Carolina Department of Health and Human Services.

**Otters H, Schellevis F, Damen J, van der Wouden J, van Suijlekom-Smit L & Koes B** (2005). Epidemiology of unintentional injuries in childhood: a population-based survey in general practice. *The British Journal of General Practice*, 55 (517), 630-3.

**Petridou E, Alexe D M, McDaid D, Segui-Gomez M and the Task Force on Burden of Injuries (BOI) of the European Commission Working Party on Accidents and Injuries (WP-AI)** (2005). Burden of Fatal Injuries In The European Union. Report prepared for the European Commission, DG SANCO. Athens, Greece.

**Reading R, Langford I, Haynes R & Lovett A** (1999). Accidents to preschool children: comparing family and neighbourhood risk factors. *Soc Sci Medicine*, 48(3), 321-30.

## Risk factors in children's accidents leading to emergency treatment in hospital

**Reimers A, Laflamme L** (2005). Neighbourhood social and socio-economic composition and injury risks. *Acta Paediatr*, 94(10), 1488-94.

**Roberts I** (2005) Trauma care research and the war on uncertainty. *BMJ*, 331,1094-1096.

**Thanh N, Hang H, Chuc N, Byass P & Lindholm L** (2005). Does poverty lead to non-fatal unintentional injuries in rural Vietnam?, *International Journal of Injury Control and Safety Promotion*,12(1), 31-7.

**Unicef** (2001). A league table of child deaths by injury in rich nations, Innocenti report card, Is.2, Innocenti Research Centre, Florence.

**Washington State Department of Health Maternal and Child Health Assessment** (2006). Maternal and Child Health Data and Services Report. Available at: [www.doh.wa.gov/cfh/mch/mch\\_assessment/mchdatareport/mch\\_datareport\\_2006.pdf](http://www.doh.wa.gov/cfh/mch/mch_assessment/mchdatareport/mch_datareport_2006.pdf) [accessed 10/08/09]

**Wazana A** (1997). 'Are there injury-prone children? A critical review of the literature'. *Canadian J Psychiatry*, 42, 602-610.



# Egg-borne outbreak of *Salmonella enteritidis* (PT6) in a nursing home: the need to continue reinforcing good food handling and hygiene practices

Dr Julian Elston<sup>1</sup> BSc MSc (Dist) PhD MPH, Mike J Wade<sup>2</sup> BSc MA Dip SW, Dr Anders Wallensten<sup>3,4</sup> MD PhD, Katherine O'Connor<sup>5</sup> BSc MCIEH

<sup>1</sup> Peninsula Technology Assessment Group (PenTAG), Peninsula College of Medicine and Dentistry, Barrack Road, Exeter

<sup>2</sup> Public Health Development Unit, NHS Plymouth, 18 Catherine Street, Plymouth

<sup>3</sup> Health Protection Agency South West, The Wheelhouse, Bond's Mill, Stonehouse, Gloucester

<sup>4</sup> European Programme for Intervention Epidemiology Training (EPIET), European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden

<sup>5</sup> Environment and Planning Department, Plymouth City Council, Plymouth

**Correspondence:** Dr Julian Elston, Honorary Research Fellow and Academic Specialty Registrar in Public Health, PenTAG, Peninsula College of Medicine and Dentistry, 3rd Floor, Noy Scott House, Royal Devon and Exeter NHS Foundation Trust, Barrack Road, Exeter EX2 5DW, England. Telephone: +44 (0)1392 406914. Email: julian.elston@nhs.net

## Abstract

### Background

*Salmonella enteritidis* infection can cause severe diarrhoea and dehydration, and, in vulnerable people, may result in death. Although fatality rates are generally low, in nursing and residential homes they can be considerably higher. Eggs and poultry are the main source of infection. Preventative measures have reduced the risk posed by eggs over the past decade, although outbreaks continue, often via imported eggs. The susceptibility of residents relates to their generally poorer health, intimate domestic environment and dependence on shared services, all of which can facilitate transmission. This paper reports on an outbreak of *Salmonella enteritidis* (phage-type 6) at a nursing home in South West England, and identifies the source and mode of transmission.

### Methods

Following laboratory notification of salmonellosis at a nursing home, environmental health and Health Protection Agency staff undertook a joint site visit. Environmental and microbiological investigations were conducted and preventative measures put in place. A cohort study was conducted with staff and residents to identify the possible route of transmission, with resident exposure assessed by staff in all but two cases.

### Results

Microbiological investigations confirmed PT6 in uncooked eggs in the fridge, and on a dishcloth and tea towel in the kitchen. Nine people (five residents and four staff) had positive stool samples for *Salmonella enteritidis* (PT6); two were hospitalised. The epidemic curve suggested either an ongoing source or a point source of infection with person to person transmission. All 32 staff and residents participated in a cohort study. Relative risks for the point source did not support a strong association with any individual food item, supporting the hypothesis that more than one route was involved.

### Conclusion

Although measures to control and prevent the contamination of eggs with salmonella have reduced the risk of infection, this study highlights the ongoing need for promoting best practice in food handling and ensuring catering standards, especially in institutions caring for vulnerable populations, if serious outbreaks are to be prevented.

**Key words:** Cohort study; environmental health; nursing home; *Salmonella enteritidis* PT6

## Introduction

Non-typhoidal salmonella infection is usually a self-limiting gastroenteritis, marked by symptoms of diarrhoea, nausea and vomiting, abdominal pains, fever and headache. It can lead to hospitalisation in dehydrated patients and occasionally result in death. Although in *Salmonella enteritidis*, the most common foodborne infection in the UK, the case fatality rate is low (0.4-0.6%), it can be considerably greater in susceptible groups such as infants, the immuno-compromised and the elderly. Nursing homes and hospitals, in particular, have high mortality rates, with rates 70 times higher than the wider population (Gil *et al.*, 2009; Mishu *et al.*, 1994).

*Salmonella enteritidis* is commonly acquired by ingesting uncooked or raw eggs either directly or by contaminated fomites. Person-to-person transmission can also occur when symptomatic individuals have poor hygiene (Health Protection Agency, 2009b), especially if involved in food preparation or if they have learning or cognitive difficulties.

In the 1980s and early 1990s, salmonellosis was a leading cause of infectious intestinal disease in residential homes, leading to more hospital admissions and deaths compared with other outbreaks of intestinal infections (Levine *et al.*, 1991; Strausbaugh *et al.*, 2003). Residents of nursing homes are a particularly vulnerable to infection because of their generally poor physical health, age-related achlorhydria and their dependence on shared facilities like bathrooms and services such as laundry and catering (Strausbaugh *et al.*, 2003).

Over the past decade, a number of preventative measures have been introduced to reduce the level of community infections in the UK. In the mid-1990s, vaccination programmes against *S. enteritidis* phage-type 4 (PT4), then the predominant cause of human salmonella infection in the UK, were established in broiler breeder and commercial laying poultry flocks. In 2002, UK guidance on food-handling and catering standards, particularly relating to eggs, was produced (Food Standards Agency, 2002). Subsequently, the incidence of *S. enteritidis* cases in England and Wales fell by 66%, primarily through a reduction in PT4 cases. However, this has been accompanied by a doubling of the incidence of lower prevalence non-PT4 infections (Gillespie, 2004). Nevertheless, egg-borne outbreaks continue (Calvert *et al.*, 2007), suggesting that, despite the inherently lower risk of infection from eggs, other control measures to reduce transmission are not being adhered to.

This paper describes an egg-borne outbreak of *Salmonella enteritidis* phage-type 6 (PT6) in a nursing home in the South West region of England. The investigation raises a number of issues relating to infection control in eggs, particularly in vulnerable populations.

## Methods

Following the notification of two confirmed cases of salmonella infection at a nursing home, environmental and microbiological investigations were promptly instigated by local environmental health and Health Protection Agency (HPA) staff in order to identify the possible source of infection and to implement measures to prevent further cases. A cohort study was subsequently conducted to establish the infection's source and mode of transmission.

### Environmental investigation

Communal areas, particularly the kitchen, were thoroughly inspected, and cleaning and storage facilities such as the refrigerator were checked. Cleaning and cooking rotas were obtained and reviewed. Kitchen surfaces were swabbed and general purpose cloths and three batches of eggs in the refrigerator, some without printed codes on their shell, were taken for microbiological analysis. The eggs were purchased from a local shop

### Microbiological

Stool samples were requested and obtained from all staff (who worked during the outbreak period) and symptomatic residents, and their GPs notified. All samples were tested for enteric pathogens using standard laboratory methods. These include direct inoculation of a one in 10 suspension of the faeces onto Xylose Lysine Deoxycholate (XLD Oxoid number POO164A) and enrichment using Selenite F Broth (Oxoid number EBO354E), which was then inoculated onto XLD after 24 hours' incubation (BSOP 30, BSOPID 24 [FSA, 2008]). Suspected salmonellas were identified biochemically and serologically using 'O' and 'H' antisera, before being submitted on solid nutrient agar to the Laboratory for Enteric Pathogens, HPA Centre for Infections, for confirmation and phage typing (Ward *et al.*, 1987).

Swabs, eggs and cloths were examined for salmonella at the Food, Water and Environmental Laboratory at

Plymouth Hospitals NHS Trust using HPA Standard Operating Procedure 214 – isolation of salmonella from foodstuffs.

### Cohort study

An adapted HPA food poisoning questionnaire was administered by laptop to staff and residents present during the outbreak period – defined by the period three days before the first confirmed case (to allow for the incubation period (Hawker *et al.*, 2005)) to the day of symptom onset reported in the last two cases (in total one week). Questionnaires included items on food consumption (using the daily menus during the outbreak period), contact with people with gastroenteritis, recent travel, and any symptoms of salmonellosis. Residents' questionnaires were completed by senior care workers as cognitive limitations meant all but two were unable to remember their food consumption two weeks after the outbreak period. Where available, answers were corroborated using entries in residents' files or with other members of staff. Two clients were excluded from the study as they were fed special processed food, not prepared on site, via gastrostomy tubes. All staff handled food with no responsibility for serving specific residents. Records of interaction between staff and residents and residents themselves were not kept.

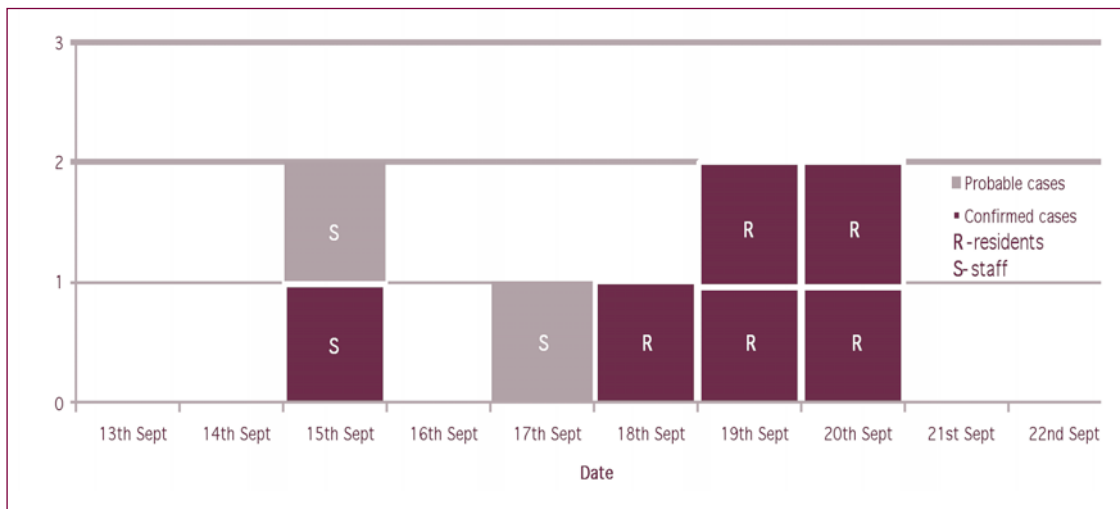
For the analysis, probable cases were defined as residents or staff working during the outbreak period and reporting diarrhoea (three or more loose stools in 24 hours). Other symptoms of salmonellosis (fever, nausea, vomiting, bloody stool, abdominal pain) were not used as these were not commonly shared. Confirmed cases were defined as individuals with a positive stool sample for salmonella. Cases were included only if symptoms occurred within the defined outbreak period.

Relative risks and attack rates with 95% confidence intervals (95% CI) were calculated using *EpiData* v3.1 (Lauritsen, 2000-2008). Cases (confirmed or confirmed and probable) and non-cases (staff, residents or both) included in the analysis depended on the item under investigation and the time period for likely exposure. The null hypothesis – no increase in relative risk – was rejected when  $p < 0.05$  using the Fisher's exact test (two-sided).

## Results

The findings from the environmental and microbiological investigation informed the analysis of the cohort study.

Egg-borne outbreak of *Salmonella enteritidis* (PT6) in a nursing home: the need to continue reinforcing good food handling and hygiene practices



**Figure 1.0**  
Epidemiological curve of *Salmonella Enteritidis* outbreak at a nursing home

Note: three confirmed cases were not included in the curve as they did not report symptoms so their date of onset was not known.

**Environmental investigation**

The kitchen inspection identified a number of problems. The sink for hand washing was difficult to reach and dry when examined. Surfaces and cloths were dirty and the deep-cleaning rota had not been completed for three months. The temperature of the fridge was documented as 6 °C but when measured was 11 °C. A number of eggs found in the fridge were visibly contaminated with faeces and feathers. The manager reported that on the eve of the first case, residents’ food was prepared by a non-catering worker due to staff shortages, although the worker was previously employed as a cook at the home.

**Microbiological investigation**

Laboratory investigation and subsequent typing confirmed that stool samples from nine individuals at the home were positive for *Salmonella enteritidis* (phage-type 6). Five residents and one member of staff were symptomatic (100% diarrhoea, 57% abdominal pain, 43% vomiting, 29% nausea and 29% fever). The remaining three cases, who did not report symptoms, were identified through microbiological screening of staff. *Salmonella enteritidis* phage-type 6 (PT6) was also identified on a tea towel, dish cloth and in stored eggs.

Environmental health investigations revealed that the eggs were supplied by a registered wholesaler. Two of the three batches had a UK origin code printed on the

shell, one of which was from a large, reputable company with a vaccinated flock. The code on the other batch did not match any UK producer. This batch was infected with *Salmonella enteritidis* PT6. Checks with the Health Protection Agency did not identify other outbreaks of *S. enteritidis* PT6 around the period of enquiry.

**Cohort study**

A total of 32 questionnaires was completed (17 by clients and 15 by staff), giving a response rate of 74% (32/43). The mean age was 63.3 years (range 17.2-96.8 years), and 85% were female.

- 1) The epidemic curve (Figure 1.0) suggested that a point source was unlikely to be responsible for all cases as the time-lapse between the first and latter cases exceeded the typical incubation period of 12-72 hours (Health Protection Agency 2009a). Given environmental and microbiological findings showing the same phage-type of salmonella in eggs and on contaminated cloths, and that the staff and residents reported no recent travel-associated diarrhoea or contact with people with gastroenteritis, Figure 1.0 suggested four possible routes of transmission:
- 2) Two point sources; one affecting staff between 13th-15th September and one affecting mainly residents between 17th-20th September.
- 3) A member of staff became a case from handling eggs before the 15th September, followed by a point



Date	Menu item	Exposed			Not exposed			Relative risk	(95% CI)	P-value
		N	Total (n)	Cases	Total (n)	Cases				
17th September	<i>Breakfast</i>									
	Cereal	17	9	4	8	1	3.56	(0.49-25.59)	0.2941	
	Toast	17	6	0	11	5	0	(inf-inf)	0.1023	
	Egg (poached)	17	1	0	16	5	0	(inf-inf)	1	
	Other breakfast	17	2	0	15	5	0	(inf-inf)	1	
	<i>Supper</i>									
	Bubble and squeak	17	10	2	7	3	0.47	(0.10-2.10)	0.5928	
	Fruit crumble and custard	17	12	3	5	2	0.63	(0.15-2.67)	0.6	
Other supper	17	7	3	10	2	2.14	(0.48-9.66)	0.5928		
18th September	<i>Breakfast</i>									
	Cereal	17	9	4	8	1	3.56	(0.49-25.59)	0.2941	
	Toast	17	6	0	11	5	0	(inf-inf)	0.1023	
	Other breakfast	17	2	0	15	5	0	(inf-inf)	1	
	<i>Dinner</i>									
	Beef stew and dumplings	17	15	4	2	1	0.53	(0.11-2.70)	0.5147	
	Stewed fruit and ice cream	17	16	5	1	0	∞	(inf-inf)	1	
	<i>Supper</i>									
	Cauliflower cheese	17	10	2	7	3	0.47	(0.10-2.10)	0.5928	
	Semolina	17	15	5	2	0	∞	(inf-inf)	1	
Other supper	17	7	3	10	2	2.14	(0.48-9.66)	0.5928		

Key: inf – infinity; ∞ – infinity

Note: As all residents had the same main dishes on 17th September this meant an analysis could not be undertaken. No analysis for performed for items consumed on the 19th September because of insufficient cases (two) for a robust statistical analysis.

**Table 1.0**  
Relative risk of infection for confirmed cases presenting in residents between 18th-20th September

- 3) source outbreak on the 17th-20th September.
- 4) On-going source: cases may have become ill after eating egg-containing foods on one or more occasions.
- 5) Cases may have been caused by person-to-person transmission and/or cross-contamination of food items.

Analysis tested the first three hypotheses in turn. Hypothesis 4 could not be tested directly as person-to-person contact data was not available.

**Investigation of hypothesis 1 and 2**

No analysis was conducted for the period 13-15th

Egg-borne outbreak of Salmonella enteritidis (PT6) in a nursing home: the need to continue reinforcing good food handling and hygiene practices

	N	Exposed		Not exposed		Relative risk	(95% CI)	P-value
		Total (n)	Case	Total (n)	Case			
<i>All egg-containing foods</i>								
Residents & staff	31	25	7	6	0	∞	(inf-inf)	0.2928
Residents only	17	16	5	1	0	∞	(inf-inf)	1.000
<i>Excluding mousse and bread &amp; butter pudding</i>								
Residents & staff*	31	18	3	13	4	0.54	(0.15-2.02)	0.4130
Residents only*	17	11	2	6	3	0.36	(0.08-1.61)	0.2801
<i>Mousse only</i>								
Residents & staff	31	19	6	12	1	3.79	(0.52-27.72)	0.2015
Residents only	17	15	4	2	1	0.53	(0.11-2.70)	0.5147

**Table 2.0**  
The relative risk associated with consumption of any egg-containing meal (including and excluding mousse and bread and butter pudding and for mousse alone)

Key: inf – infinity; ∞ – infinity

Note: Seven confirmed cases were used in the analysis of residents and staff, as we included the asymptomatic confirmed case in a staff member.

September, as there were insufficient confirmed cases for a statistically robust analysis. Table 1.0 shows the relative risk of infection for confirmed cases in residents only, presenting between 18th-20th September. The member of staff and food handler (17th September) was excluded from the analysis so as to ensure transmission could be attributed to food consumption rather than direct environmental contamination in the kitchen.

Table 1.0 shows that six food items had a relative risk greater than one, suggesting their consumption was associated with an increase in risk of infection, but none of these associations reached statistical significance.

Stewed fruit and ice cream and semolina had an infinite relative risk, indicating that only residents who ate these items became infected. Other supper (e.g. soup – the only additional item to be consumed by all cases) and breakfast cereal on both 17th and 18th September were associated with relative risks of infection of 2-3, albeit with wide confidence intervals which included unity. None of these foods contained eggs, the likely source of PT6 in this outbreak. If these relative risks are real, it is possible that these foods may have been cross-contaminated during preparation or when being served.

One explanation for seeing an elevated risk on two consecutive days could be the habitual nature of residents' diets, ensuring that any breakfast item showing an elevated risk on one day is likely to show a similar increased risk the following day. However, none of our results were statistically significant, possibly due to a lack of power as there were only a small number of cases.

**Investigation of hypothesis 3**

Table 2.0 shows the relative risk associated with consuming different egg-containing meals. Individuals were defined as being exposed if they had consumed any one or more of the following items during the outbreak period: fried, poached or boiled eggs, mousse, quiche, omelette and bread and butter pudding. Associated risks were analysed for the whole cohort and for residents only, as there were insufficient cases in staff cases to analyse this group separately.

All seven cases were among the 25 residents and staff who ate egg-containing foods. As there were no cases in the six who did not eat egg-containing foods, this suggested that these may be the route of transmission. However, when egg-containing puddings were excluded

from the analysis, consumption of egg-containing breakfasts and main courses appeared to protect against infection, suggesting puddings alone might be the mode of transmission. As the mousse was made commercially, it was investigated as a single food item. This revealed an increase in relative risk for staff and residents but not residents alone. These inconclusive results suggested bread and butter pudding might have been the route of transmission, but as this dish was served on the evening of 19th September, it could only have caused the last two cases. However, none of the results were statistically significant, despite a larger cohort being used in some analyses.

## Discussion

The environmental investigation found a disorganised kitchen with faulty and un-used equipment and irregular cleaning and staffing practices. Microbiological investigations subsequently revealed that the outbreak strain of *Salmonella enteritidis* PT6, isolated from affected residents and staff, was indistinguishable from isolates found in a batch of eggs (kept in a malfunctioning refrigerator) and on kitchen cloths. This strongly suggested that eggs were the source of the outbreak.

The epidemic curve suggested four possible transmission modes including point or on-going source, cross-contamination and person-to-person spread. However, despite an apparent increase in risk from consuming four non-egg containing meals on more than one day, no results were statistically significant. Similarly, the consumption of one or more cooked meals containing egg during the outbreak period appeared to be associated with an increased risk, but these results were not statistically significant. Furthermore, the risk of infection reduced when egg-containing puddings were not included. Although this suggested these puddings might be associated with an increased risk, the mousse did not contain eggs brought into the home and the bread and butter pudding could only have accounted for two cases of infection. In addition, none of these results were statistically significant. The isolation of salmonella on the tea towel and dishcloth a week after the outbreak started and evidence of poor cleaning practice and maintenance of kitchen facilities, together with the results of the cohort study, suggested cross-contamination was the most likely mode of transmission. Person-to-person transmission was also possible but could not be explored in the analysis because of lack of data.

## Strengths and weaknesses

The main limitation of our investigation related to the cohort study. The elapsed time between consumption of food items and completion of study questionnaires may have introduced bias. In the case of residents, the need to rely heavily on staff to complete their questionnaires may have compromised their validity. However, residents were reported by staff to be consistent in their menu choices, and in a few cases residents' notes were also used, which would have improved the accuracy of responses. Nevertheless, it was possible that recall of food consumption in cases (compared to non-cases) may have been better, biasing the results.

Although the response rate was good, one confirmed case could not be interviewed as he was on annual leave. This limited the analysis relating to staff alone. Generally, the small number of cases limited the power of the study to detect effects. Finally, difficulties in establishing the time (not just the date) of onset of symptoms limited the ability to more accurately define those at risk of infection in the analysis, weakening ability to find associations between infection and specific food items.

## Policy implications

The incident is a pertinent reminder that despite the number of egg-related infections falling significantly over the past decade, salmonella can still be found in eggs purchased in the UK. A recent survey of raw shell eggs used in UK catering premises revealed that one in 335 batches (0.3%) were infected with salmonella, 88% with *S. enteritidis*, 37% of which were PT6 (Elson and Little, 2004). Although salmonella infection rates are at lower levels following widespread poultry vaccination against PT4, the relative proportion of infections from non-PT4 subspecies has doubled since 1990 (possibly through increased colonisation of breeding, laying and broiler flocks). However, a recent HPA report has implicated imported eggs in continuing outbreaks, particularly from Spain, the largest supplier of eggs to the UK (Pugh 2009). Evidence suggests that between 4.4% and 6.7% of imported Spanish eggs are contaminated – PT6 is one of the more common isolates (Elson and Little, 2004; Little *et al.*, 2007).

The source of the contaminated batch of eggs was investigated by the local authority and the local DEFRA (Department for the Environment, Food and Rural Affairs) egg inspector. There remains some doubt about the provenance of the batch infected with salmonella.

## Egg-borne outbreak of *Salmonella enteritidis* (PT6) in a nursing home: the need to continue reinforcing good food handling and hygiene practices

The presence of shell-soiled eggs suggested poor quality control mechanisms at the home, or irreverence or lack of awareness of the low but persistent risk of salmonella infection from eggs. However, the presence of salmonella in egg alone is not sufficient to cause an outbreak. The chain of infection between source and susceptible host needs to be completed. In this respect, residential or nursing homes provide an ideal environment for acquisition and spread of infection, as susceptible residents share food and water sources, and health care in a crowded setting (Strausbaugh *et al.*, 2003). Inadequate food handling practices and general kitchen hygiene, including the lack of refrigerated storage of dairy-containing food products, are key contributory factors to making the link (Frank *et al.*, 2007). In this incident these failings were exacerbated by an undersized kitchen and staffing problems. Poor practice regarding egg storage and usage appears widespread in the UK. A recent survey identified over half of salmonella-contaminated catering premises as not storing eggs under refrigeration, and a fifth storing eggs that had passed their 'best-before' dates or using eggs older than three weeks (Food Standards Agency, 2007). Even when storage practices are good, egg-containing meals need to be cooked thoroughly and pasteurised eggs used for recipes requiring raw or lightly cooked eggs to minimise the risk of transmission, especially when catering for vulnerable populations (Food Standards Agency, 2002).

Local authorities have a key role in protecting the health and well-being of clients of residential or nursing homes. This may involve, among other things, monitoring against national guidance or standards, inspection, training on food hygiene and education on good infection control practices.

This study underlines the continuing need for environmental health practitioners to work closely with the management of institutions looking after vulnerable populations to ensure actions aimed at stemming the sources of infection are adequate, and in particular:

### Source of infection

- Regular and *ad hoc* inspection of registered egg suppliers and distributors to ensure compliance with regulations and prevent illegally imported eggs entering the supply network.
- Encouraging institutions only to purchase Lion-marked eggs or eggs from a vaccinated flock, and that any soiled, feathered or unstamped eggs should be disposed of. The use of eggs from vaccinated

flocks should be a material consideration in the food safety management systems of a food business. All food handlers should be aware of the persistent risk of salmonella infection.

- Encouraging the thorough cooking of food dishes containing egg. Institutions housing vulnerable people should have a policy of using pasteurised eggs if recipes require raw or uncooked eggs.
- Emphasising the importance of maintenance and monitoring of refrigeration equipment and the types of food that should be subject to cool or cold storage.

### Mode of transmission

Ensuring that managers are aware of importance of;

- Regular, planned deep cleans of the kitchens and that all staff handling food have been on, at least, the basic level food hygiene course, in order to reduce the risk of infection foods entering into the wider kitchen environment.
- Daily laundering of tea and dish cloths on a hot wash to prevent any bacterium persisting or spreading within the kitchen environment, or the use of disposable cloths.

## Conclusion

Although national policy focus is required to support the long-term control of salmonella-infected imports, this must not detract at the local level from the continued efforts to reduce transmission using basic infection control measures. This outbreak provides evidence to support the need for sustained food handling education and awareness-raising, particularly in institutions caring for vulnerable individuals.

## Acknowledgements

Thanks to Dr Geoffrey Thould, Dr Isabel Oliver, Brenda Dale and Joy Slaughter who actively contributed to this investigation and, in the case of former, also commented on the draft paper.

## References

- Calvert N, Murphy L, Smith A and Copeland D** (2007). A hotel-based outbreak of *Salmonella enterica* subsp. *Enterica* serovar *Enteritidis* (*Salmonella Enteritidis*) in the United Kingdom (2006), *Eurosurveillance*, 12(3): 222. Available online at: [www.eurosurveillance.org/ViewArticle.aspx?ArticleId=689](http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=689) [accessed 20/07/09]

**Elson R and Little C** (2004). First United Kingdom-wide study of raw shell eggs and their use in catering premises. *Eurosurveillance*, 8(12). Available online: [www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2422](http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2422) [accessed 20/07/09]

**Food Standards Agency** (2007). UK-wide survey of salmonella in raw shell eggs used in catering premises – final report. Available online: [www.food.gov.uk/multi-media/pdfs/eggssurvey2007.pdf](http://www.food.gov.uk/multi-media/pdfs/eggssurvey2007.pdf) [accessed 20/07/09]

**Food Standards Agency** (2002). Eggs – what caterers need to know. Available online: [www.food.gov.uk/multimedia/pdfs/publication/eggscaterers1007.pdf](http://www.food.gov.uk/multimedia/pdfs/publication/eggscaterers1007.pdf) [accessed 20/07/09]

**Frank C, Buchholz U, Maass M, Schroder, Bracht K H, Domke P G, Rabsch W, Fell, G** (2007). Protracted outbreak of *S. Enteritidis* PT 21c in a large Hamburg nursing home, *BMC Public Health*, 7: 243

**Gil P R, Alejandro C G, Meca A A, Barrera V H and de Miguel A G** (2009). Epidemiology of hospital-treated salmonella infection; data from a national cohort over a ten-year period, *Journal of Infection*, 58(3):175-181.

**Gillespie I** (2004). *Salmonella enteritidis* non-phage type 4 infections in England and Wales: 2000 to 2004: Report from a multi-agency national outbreak control team. *Eurosurveillance*, 8(42). Available online at: [www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2569](http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2569) [accessed 20/07/09]

**Hawker J, Begg N, Blair I, Reintjes R and Weinberg J** (2005). *Communicable Disease Control Handbook*, 2nd Edition, Oxford: Blackwell Publishing.

**Health Protection Agency** (2009). Salmonella in humans (excluding *S. typhi*; *S. Paratyphi*) Faecal and lower gastrointestinal tract isolates reported to the Health Protection Agency Centre for Infections. England and Wales, 1990-2008. Available online at: [www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb\\_C/1195733760280?p=1191942172078](http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1195733760280?p=1191942172078) [accessed 20/07/09]

**Health Protection Agency** (2008). National Standard Method: Investigation of faecal samples for bacterial pathogens, BSCOP 30, Standards Unit, Department for Evaluations, Standards and Training. Available online at: [www.hpa-standardmethods.org.uk/documents/bsop/pdf/bsop30.pdf](http://www.hpa-standardmethods.org.uk/documents/bsop/pdf/bsop30.pdf) [accessed 20/07/09]

**Health Protection Agency** (2008). National Standard Method: Identification of *Salmonella* Species, BSOPID 24, Standards Unit, Department for Evaluations, Standards and Training. Available online: [www.hpa-standardmethods.org.uk/documents/bsopid/pdf/bsopid24.pdf](http://www.hpa-standardmethods.org.uk/documents/bsopid/pdf/bsopid24.pdf) [accessed 20/07/09]

**Health Protection Agency** (2009). Salmonella – Clinical Information. Available online at: [www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1191942172066?p=1191942172066](http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1191942172066?p=1191942172066) [accessed 20/07/09]

**Lauritsen JM** (2000-2008). EpiData data entry, data management and basic statistical analysis system. Odense Denmark, EpiData Association. Available online at: [www.epidata.dk](http://www.epidata.dk) [accessed 20/07/09]

**Levine W C, Smart J F, Archer D L, Bean N H and Tauxe R V** (1991). Foodborne disease outbreaks in nursing homes, 1975 through to 1987, *JAMA*, 266(15):2105-2109.

**Little C L, Walsh S, Hucklesby L, Surman-Lee S, Pathak K, Gatty, Y** (2007). Survey of salmonella contamination of non-united kingdom-produced raw shell eggs on retail sale in the northwest of England and London, 2005 to 2006, *Journal of Food Protection*, 70: 2259-2265.

**Mishu B, Koehler J, Lee L A, Rodrigue D, Brenner F H, Blake P** (1994). Outbreaks of *Salmonella enteritidis* infections in the United States, 1985-1991, *Journal of Infectious Diseases*, 169(3):547-552.

**Pugh S** (2009). Surveillance for salmonella in eggs. Microbiology Safety Division, Food Standards Agency. Available online at: [www.defra.gov.uk/animalh/diseases/zoonoses/meeting/spugh-abstract.pdf](http://www.defra.gov.uk/animalh/diseases/zoonoses/meeting/spugh-abstract.pdf) [accessed 20/07/09]

**Strausbaugh L J, Sukumar S R and Joseph C L** (2003). Infectious disease outbreaks in nursing homes: an unappreciated hazard for frail elderly persons, *Clinical Infectious Diseases*, 36(7):870-876.

**Ward L R, de Sa J D and Rowe B** (1987). A phage-typing scheme for *Salmonella enteritidis*, *Epidemiology and Infection*, 99(2):291-294.

# CIEH funding for research projects

## CIEH funding for research projects

The CIEH sets aside a budget each year to support environmental health research. If you would like further information and/or to apply for support for a research projects, please contact Gary Telfer at [g.telfer@cieh.org](mailto:g.telfer@cieh.org) or on 0207 827 5842. The maximum grant available is £3,000

The criteria for applications are as follows:

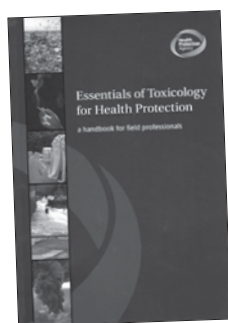
### Procedure & conditions of grant applications

- i) CIEH members only are eligible for Research Grant aid.
- ii) Applications in an agreed format are to be made in advance.
- iii) Eligible costs include legitimate expenses, but exclude tuition and course fees.
- iv) Payment will be made on receipt of invoices or written evidence of expenditure.
- v) Grant instalments will be paid, up to a maximum of 75% of the total grant, before receipt of the completed research paper offered for possible publication in JEHR. The balance will be paid on publication or at such other time as agreed.

### Assessment criteria

Each case will be judged on its merits. The awarding body will wish to consider:

- The extent to which the research is likely to contribute to the knowledge-base of environmental health;
- Value for money in relation to the proposed expenditure;
- Whether the methodology is appropriate and robust;
- The proposed timescale; and
- Any other relevant matter.



### Essentials of Toxicology for Health Protection: A Handbook for Field Professionals

**David Baker, Robin Fielder, Lakshman Karalliedde, Virginia Murray, Norman Parkinson (Editors). Published by the Health Protection Agency, UK.**

**ISBN 978 0 901144 72 0. 2008. £19.99.**

Toxicology is an expansive, multidisciplinary field encompassing biology, medicine, chemistry, environmental science, public health and other basic and applied disciplines. The breadth of the field lends to its appeal for those of us who make it our profession. Yet, it also proves daunting for the student of toxicology as well as authors attempting to create text that is a concise, practical overview of the field. The great challenge for authors is to pare down an overwhelming amount of interrelated information without sacrificing accuracy and understanding.

In light of this challenge, the multiple editors and authors of "Essentials of Toxicology for Health Protection" have succeeded in producing an accurate, highly useable text that lives up to the term 'essentials'. The target audience, as noted in the subtitle, is field professionals, such as emergency responders, public health workers and local authorities in health protection. The aim of the text is to provide a working knowledge of toxicology, emphasising fundamental principles of how exogenous chemicals interact with the human body, practical applications of toxicology practice and a survey of toxic agents, with a focus on chemical incidents and chronic exposures.

The text is divided into four chaptered sections: Fundamentals, Applications, Environmental Toxicology,

and a Review of Toxic Agents. This structure loosely mirrors that of seminal texts in toxicology (e.g., Casarett & Doull's Toxicology: The Basic Science of Poisons), and has proven to be a practical approach. The first section on fundamentals deals with basic concepts regarding the study of adverse effects of chemicals on the body, such as exposure, dose, dose – response relationships, and toxicity to target organs. In keeping with the practical aspects of the text, also included is a chapter on human biomonitoring of chemical exposure.

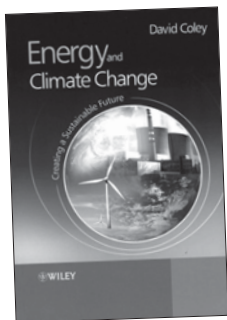
The second section on Applications of Toxicology is devoted to sources of toxicological information, medical management of chemical incidents, and concepts of susceptibility and exposure assessment. The chapter on information sources will be highly useful to readers, pointing them to reliable, government and university sponsored internet sources (and, commendably, warning readers of the plethora of unreliable toxicological information on the internet). The third section on Environmental Toxicology presents the reader with chapters on occupational toxicology, air pollution, contaminated land and other topics that health protection professionals are likely to encounter. The fourth section, Review of Some Toxic Agents, similarly surveys typical chemicals and situations that users of the text will likely encounter in their work, such as carbon monoxide, heavy metals, and pesticides. It also presents areas of recent concern, such as chemical weapons and traditional medicines.

As a "handbook for field professionals", the text is a success as a useable source of toxicology information and common language for diverse health protection professionals. The writing could have used more careful editing in places, and I sometimes questioned the emphasis. For example, the chapter on experimental methods may not be of practical importance for the intended audience, and there is a tension in some chapters between simply giving information and being a 'how to' guide. In a broad field such as toxicology, the need to divide & categorise concepts is a necessary evil, and as an instructor of toxicology I didn't always agree with the choices made here. However, health protection professionals will use, rather than simply read, this handbook, as it provides a wealth of basic, practical information about a fascinating, and highly pertinent, field of practice.

**Daniel M Tessier, Ph.D., DABT.**

Principal Investigator, Environmental Safety Assessment, DuPont Crop Protection, EI DuPont de Nemours and Co, Wilmington, Delaware, USA.





## Energy and Climate Change: Creating a Sustainable Future

**David Coley. Published by John Wiley and Sons.**

**ISBN: 978 0 470 85313 9. 2008. 672 pages, £34.95**

I cannot remember the last time when I sat down and read a complete textbook. This one didn't tell me anything new, but it brought the argument, problems and potential solutions between two covers. Substantial elements of the material can be found elsewhere, for example Boyle *et al.*, and Twidell and Weir. While at first I felt cheated, I came to realise that the author was aiming at a book useful to all those who need to know the effect energy use has on the climate, and the other issues relating to energy use, namely that it is a finite and hence diminishing resource.

The book is split into four sections. The first gives an excellent introduction to energy, sustainability and climate change and also introduces the economics. So this book, from the start, while it does address issues that for some are still worth debating, does demand that we base our alternatives on a sound financial footing.

Part II outlines the traditional energy generating technologies, the remaining resources and resultant pollution. There is a chapter on transport, an inescapable problem considering that it is the single largest contributor to carbon dioxide emissions in the UK. Part III looks at the impact of continued energy use from traditional sources and the various international agreements such as Kyoto. Part IV considers some of the various alternative technologies, giving an introduction to the topic including energy efficiency, renewable energy systems – solar, wind, wave, tidal, small-scale hydro, biomass and geothermal. It also discusses fast

breeder and fusion nuclear reactors, hydrogen and carbon sequestration.

The author is honest in his assessment of technologies. He uses problems throughout to prompt readers to undertake their own learning on a subject, which can be far more rewarding and pedagogically more useful as a learning exercise. He includes well-thought-out student exercises to extend the learning further. The problem with publishing such a book is that it can become out of date very quickly. This is overcome in the area of reserves to production ratio statistics through the use of a linked website for the book.

There are some downsides. While there is a good bibliography and reference list, a list of journals, that students should peruse to obtain up-to-date knowledge would have been of benefit in a field that sees constant development and innovation. A growing trend in book publishing is the use of sub-standard scanned images where once this would have been unacceptable, and at times there are mistakes, one relating to a missing heading without which you read and re-read the section until you realise that there are two different subjects. These issues I would suggest point to sloppy editing, which is a pity. That said, they do not take away from the worthiness of this book.

The reviewer is a course director of an engineering programme with substantial energy content, who will be placing this text on the 1st year reading list, thereby moving a number of other texts to later years of study. For students and professionals who are in need of knowledge about what are our traditional energy sources, issues of energy and climate change, and renewable energy and their effect on us and the climate, then it is an excellent reference. For the environmental health professional, having an understanding of energy generation and its pollutants, the effect of energy use on the climate, security of supply and alternative sources of energy, will greatly enhance professional judgement. This book can aid in that process.

**Dr Philip Griffiths**

Reader in Energy Storage Technology Integration,  
University of Ulster, Northern Ireland.

## Notes for authors

### Aims and scope of the Journal

The Journal of Environmental Health Research (JEHR) is published by the Chartered Institute of Environmental Health (CIEH). The Journal publishes original research papers, technical notes, professional evaluations, review articles and workshop/conference reports covering the diverse range of topics that impact on environmental health.

A new category of paper for 2009 is the 'first-author, first paper' which is designed to encourage new authors by providing more active and tolerant editorial support when a manuscript is submitted. Authors in this category are encouraged to inform the editors at the time of submission.

Particular emphasis is placed on applied research and reviews that facilitate the improved understanding of a particular aspect of environmental health. It is intended that the Journal will help to promote improvements in the professional practice of environmental health as well as contribute to the research knowledge base.

### Invitation to contributors

Contributions are invited on any of the diverse aspects of environmental health including occupational health and safety, environmental protection, health promotion, housing and health, noise and health, public health and epidemiology, environmental health education, food safety, environmental health management and policy, environmental health law and practice, sustainability and methodological issues arising from the design and conduct of studies.

Contributions should have the potential to improve practice through the dissemination of the results of research projects, reviews based on scholarly reflection and technical notes and professional evaluations which provide critical insights into practice issues. It is likely that most papers published will be based on work carried out as part of a research project or programme associated with an academic or other research institution.

Contributions are expected to be of a high standard, not only in respect of subject matter and its treatment, but also in the quality of the writing. Particular attention should be paid to clarity and conciseness of expression.

### Originality

Only original articles are considered for publication. Submission of a manuscript represents certification on the part of the author(s) that the article submitted has not been published, nor is being considered for publication, in another similar journal. Contributions may, however, be based on a prior conference presentation. A statement confirming originality should accompany the manuscript.

### Peer review

All contributions that are considered by the editors to be within the aims and scope of the Journal are subjected to peer review by at least two reviewers. It is likely that one reviewer will have an academic research background and the other a practitioner or management background. Decisions on publication are made by the editors, who are informed by the comments of the reviewers and the responses from the author(s) to the peer review reports.

### Style

These notes are intended to guide authors in some details of presentation so that papers conform to a consistent Journal style. More details on style and paper preparation can be accessed at [www.jehr-online.org](http://www.jehr-online.org).

Authors must comply with the style requirements in every respect. For example, manuscripts that are too long, have too many headings or tables or references that do not fully conform to the Harvard protocol will be returned to the author(s). Thus authors are encouraged to study these notes and those on-line carefully while preparing their manuscripts.

### Length

- Research papers: 3,500 to 6,000 words.
- Professional evaluations and Technical Notes: not normally more than 3,000 words.
- Literature Reviews: up to 6,000 words, but preferably shorter.
- Workshop/conference reports: up to 2,000 words.

### Tables, charts and photographs

These should be kept to a minimum consistent with the concise nature of the papers published in this Journal.

### Language

Manuscripts are accepted in English only.

# Notes for authors

## Book review recommendations

## Invitation to peer reviewers

## Letters to the editor

### Layout/sequencing

The manuscript should normally be sequenced as follows: Title; Author(s); Abstract (300 words +/-10%); Key words (up to 8); Introduction; main exposition (typically this section consists of the Methods and Results); Discussion; Conclusions; Acknowledgements; References.

Further essential details on each of these is available at [www.jehr-online.org](http://www.jehr-online.org) and in:

**Harvey H D and Fleming P** (2007). Writing for JEHR – an update and reminder for prospective authors. *Journal of Environmental Health Research*, 6 (1), 49-55.

### Electronic submission

The submission of manuscripts will normally be by email and word processed file attachment only, with no requirement for the submission of printed copies. The word processed document should conform to the following specification to facilitate the peer review process and editing;

- MsWord [2003](.doc) is the preferred word processor format but WordPerfect (.wpd) and Rich Text Format (.rtf) are acceptable.
- Times New Roman, 12 point, Single spacing.
- Do not indent paragraphs, do not number the pages nor insert headers or footers.
- The cover page should give the title of the paper, the name(s) and affiliations of the authors plus an Email address, telephone number and postal address for the corresponding author. Add a page break at this point and go on to the First Page.
- The First Page should repeat the Title only (not the author's details) plus the Abstract, Key Words and continue into the Introduction and the remainder of the manuscript.
- All tables, charts and photographs should be included as part of the manuscript file, unless there is a pressing technical reason for having separate graphics files.
- The file should be named with the name of the first author e.g. Wilson.doc.
- Email to Editor in Chief at [haroldharvey@yahoo.com](mailto:haroldharvey@yahoo.com) and [haroldharvey@gmx.com](mailto:haroldharvey@gmx.com) or submit via the website [www.jehr-online.org](http://www.jehr-online.org).

Communication from the editors will normally be by email only.

### Book review recommendations

Have you found a new book that you think would be worth reviewing by JEHR? Have you produced a book that you would like to be considered for review by JEHR? If so, please contact the Editor at [haroldharvey@gmx.com](mailto:haroldharvey@gmx.com) and [haroldharvey@yahoo.com](mailto:haroldharvey@yahoo.com) for details of the review process.

### Invitation to peer reviewers

JEHR operates the double-blind peer review process. When a manuscript is received from the author(s), it is sent to specialist reviewers whose identities are not known to the author and the identity(ies) of the author(s) are not known to the reviewers – thus the 'double blind' terminology. Only the editor knows both the identity of the author(s) and those reviewing the manuscript. This is designed to assure the independence and objectivity of the review process. Wherever possible, we like to select one academic reviewer and one practitioner reviewer for each manuscript submitted.

As a result of the increasing number of submissions to JEHR, we would like to supplement our panel of reviewers in both categories. If you would like to be considered for the Peer Review Board, please send a short CV and a covering email to indicate which subjects you would feel confident about reviewing to [hd.harvey@ulster.ac.uk](mailto:hd.harvey@ulster.ac.uk) and [haroldharvey@gmx.com](mailto:haroldharvey@gmx.com). There is a small thank-you remuneration for each review carried out.

### Letters to the editor

The editors welcome letters on the content of published papers, on general matters relating to the Journals and on environmental health research issues. Please email your contributions to Dr H Harvey, Editor in Chief, at [haroldharvey@yahoo.com](mailto:haroldharvey@yahoo.com), [haroldharvey@gmx.com](mailto:haroldharvey@gmx.com) or via the website [www.jehr-online.org](http://www.jehr-online.org).

# The Journal of Environmental Health Research

ISSN 14760932 Volume 09 Issue 02

## Editorial

Editorial Team profiles

64

Editorial

67

David Statham

## Papers

Lay perceptions of health, housing and community on the Kent coast, England

69

DR JILL STEWART AND PROFESSOR LIZ MEERABEAU

Oxidative stress and antioxidants status of occupational pesticides exposed  
sprayers of grape gardens of Western Maharashtra (India)

81

DR JYOTSNA A PATIL, DR ARUN J PATIL, DR AJIT V SONTAKKE, DR SANJAY P GOVINDWAR

Distribution pattern of a dengue fever outbreak using GIS

89

C D NAZRI, I RODZIAH, A HASHIM

The impact of chemical treatments on the wear, gloss, roughness,  
maintenance, slipperiness and safety of glazed ceramic tiles

97

DR FRANÇOIS QUIRION, ANDRÉ MASSICOTTE, SOPHIE BOUDRIAS, PATRICE POIRIER

## First-time, first author paper

Risk factors in children's accidents leading to emergency treatment in hospital

111

TRIANAFILLIA T GLANIA, THEODOROS LIALIARIS, GRIGORIOS TRIPSIANIS  
AND THEODOROS C CONSTANDINIDIS

## Professional evaluation

Egg-borne outbreak of *Salmonella enteritidis* (PT6) in a nursing home:

121

the need to continue reinforcing good food handling and hygiene practices

DR JULIAN ELSTON, MIKE J WADE, DR ANDERS WALLENSTEN, KATHERINE O'CONNOR

## CIEH funding for research projects

Criteria and process

129

## Book reviews

Essentials of Toxicology for Health Protection: A Handbook for Field Professionals

130

reviewed by Dr Daniel M Tessier

Energy and Climate Change: Creating a Sustainable Future

131

reviewed by Dr Philip Griffiths

## Notes for authors and invitation to contributors

132

## Invitation to peer reviewers

133

## Letters to the editor

133



Chartered  
Institute of  
Environmental  
Health

Chartered Institute of Environmental Health  
Chadwick Court 15 Hatfields  
London SE1 8DJ

Telephone 020 7928 6006

Fax 020 7928 6953

Email [education@cieh.org](mailto:education@cieh.org)

Web [www.cieh.org](http://www.cieh.org)