FACTORS ASSOCIATED WITH HOSPITAL MORTALITY DUE TO ROAD TRAFFIC ACCIDENTS AMONG PEDESTRIANS IN SOUTHERN THAILAND

Sunee Kraonual[1,2], Apiradee Lim[1,2] and Wichayaporn Thongpeth[1]

[1]Department of Mathematics and Computer Science, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani Province; [2]Centre of Excellence in Mathematics, Commission on Higher Education, Bangkok, Thailand

Abstract. Pedestrians who walk near roads are at increased risk for injury by vehicles. In this study we aimed to identify factors and injuries associated with road traffic accident mortality among pedestrians in southern Thailand who received medical treatment in order to inform policy makers on preventing road traffic mortality. Study subject inclusion criteria were injured pedestrians admitted to the general hospitals in five provinces of southern Thailand during 2008-2013. Injured pedestrians with unknown survival status were excluded from this study. The data were obtained retrospectively by reviewing the 2008-2013 Injury Surveillance (IS) database of the Office of Disease Prevention and Control (ODPC) Region 11. Logistic regression analysis (with significance set at $p<0.05$) was used to determine associations between injuries and mortality. A total of 2,777 subjects were included in the study; 59.3% males. The mean (±standard deviation) age of study subjects was 29.3 (±22.9) years. The mortality rate among study subjects was 3.6%. The factors significantly associated with mortality were: an injury time during 18:00-24:00, older age, being hit by a 4-wheeled vehicle, having penetrating or a combination of blunt and penetrating injury and having a head or neck injury italics (p <0.001). These factors need to be taken into consideration when developing programs to prevent pedestrian traffic mortality.

Keywords: pedestrian, mortality, traffic accident, determinants, southern Thailand

INTRODUCTION

Pedestrians who walk along roads are at greater risk for injury and death caused by vehicles using the same road. Approximately 23% of injury-related mortality world-wide occurs in pedestrians walking along roads; these vary by location, with Africa comprising 40% of all injuries followed by 27% in Europe, 22% in America, 14% in Southeast Asia and 8% in Thailand (WHO, 2018).

Determinants of pedestrian traffic mortality have been reported to include demographic factors and injury characteristics (Qirjako *et al*, 2008; Olszewski *et al*, 2015; McWade *et al*, 2017; Schlottmann *et al*, 2017; Roudsari *et al*, 2004; Chandran *et al*, 2012; Saidi *et al*, 2014). Elderly people involved in pedestrian traffic injuries have a higher

Correspondence: Apiradee Lim, Department of Mathematics and Computer Science, Faculty of Science and Technology, Prince of Songkla University, Pattani Campus, Pattani 94000, Thailand
Tel: +66 (0) 7333 3329; Fax: +66 (0) 7333 5130
E-mail: apiradee.s@psu.ac.th

risk of serious injuries and mortality (Haleem *et al*, 2015; Martínez-Ruiz *et al*, 2019; Charters *et al*, 2018). Most pedestrian traffic injuries occur when the pedestrian is crossing the road, especially at night or in darkness, when there is a lack of road-lighting and low visibility (Martínez-Ruiz *et al*, 2019; McWade *et al*, 2017).

Head and neck trauma are the most common causes of mortality in pedestrian traffic injuries (Yadollahi *et al*, 2017; Hasani *et al*, 2017). Pedestrians struck by pickup trucks, vans or light trucks are at a higher risk of severe injury and mortality (Roudsari *et al*, 2004; Desapriya *et al*, 2010; Damsere-Derry *et al*, 2010). Blunt injuries are the most common type of pedestrian traffic injuries (Dragu *et al*, 2009; Ehsaei *et al*, 2014; Sae-Tae *et al*, 2018) but penetrating injuries alone or in combination with blunt injuries carry a higher risk of mortality than blunt injuries alone (Ehsaei *et al*, 2014; Peng *et al*, 2015).

In 2013, Thailand had the world's second highest road accident death rate of 36.2 per 100,000 population, of whom 8% were pedestrian traffic injuries (WHO, 2015). However, studies of pedestrian traffic injuries resulting in death in Thailand are limited. In this study we aimed to identify factors associated with hospital mortality due to road traffic accidents among pedestrians in southern Thailand in order to inform policy makers on preventing road traffic mortality in this group.

MATERIALS AND METHODS

Data source

The data used in this study were obtained retrospectively from hospital-based records of traffic injuries recorded in the Injury Surveillance (IS) database during 2008-2013 from reports to the Office of Disease Prevention and Control (ODPC) for Thailand, Region 11, which covers some of the provinces in southern Thailand. The data were collected from general hospitals in five provinces of southern Thailand using an injury surveillance form, with injury characteristics recorded by nurses who interviewed patients and/or bystanders. Factors recorded for each study subject were: age, gender, type of injury, date and time of injury, type of accident, injury mechanism, body region affected and survival after receiving treatment. Subjects who died comprised: those who died before receiving treatment, those who died in an emergency department (ED) and those who died in the inpatient department (IPD). All injured pedestrians admitted to the general hospitals in five provinces of southern Thailand during 2008-2013 were included in this study. Subject exclusion criteria were pedestrians with unknown survival status. A total of 2,777 pedestrians met inclusion criteria for our study. Of these, 100 subjects died from road traffic accident injuries.

Factors analyzed to determine if they were associated with mortality were: year of injury, time of injury, gender, age group, type of accident, mechanism of injury and body region injured. Times were grouped as follows: 00:01-6:00, 06:01-12:00, 12:01-18:00, and 18:01-24:00. Ages were classified as: aged <20 years, 20-39 years, 40-59 years, and ≥60 years. The type of accident was categorized as being: hit by a motorcycle, hit by a vehicle (car, van, minivan, bus or truck) with at least 4 wheels, hit by some other form of transportation (*eg* train or agricultural vehicles) and unknown. The mechanism of injury was grouped into: blunt injury, penetrating injury and both blunt and penetrating injury. The body region

injured was categorized as: head and neck, face, chest, abdomen and pelvis, extremities and pelvic girdle, external injuries and unknown.

Statistical analysis

Descriptive statistics were used to describe variables. In this study, determinants of subject death were comprised of patient demographic factors and injury characteristics, and the outcome variable was defined as subject death due to the traffic accident. Chi-squared tests were used to calculate significant associations between determinants and the outcome. Logistic regression analysis was used to determine strengths of the associations between determinants and the outcome variable. Weighted sum contrasts (Tongkumchum and McNeil, 2009) were used to determine confidence intervals (CI) comparing the level of each factor with the overall level. We converted the coefficients from the logistic model to proportions presented as percentages, where the 95% CI for each determinant factor was classified as exceeding, crossing, or falling below the overall mortality mean. A plot of the 95% CI was created to provide a clear picture of associations rather than showing coefficients in a table. The area under the receiver operating characteristic (ROC) curve was used as a measure of goodness-of-fit. All statistical analyses and figures were created using the R program, version 3.1.3 (R Development Core team, 2015).

Ethical approval

This study was approved by the Research Ethics Committee of Suratthani Hospital (IRB approval number 62/2562).

RESULTS

A total of 2,777 subjects were included in this study; 59.3% males. Of these, 100 (3.6%) died and 2,677 (96.4%) survived. The mean (±standard deviation) age of subjects was 29.3 (±22.9) years. Forty-three point two percent of the accidents occurred during 12.00-18.00. The main mechanism of injury was blunt force trauma (91%). Fifty-eight percent of subjects were injured by motorcycle. Extremities/pelvic girdle/external injuries accounted for 65.5% of the total injuries.

No significant association was found between mortality and year of injury or gender (Table 1). Of those who died, 67% were males, of those who did not die, 59.1% were males (p=0.112). The largest age group of those who died was those aged 40-59 years (33.0%) and of those who did not die the largest age group was those aged <20 years (p <0.001). The most common time of accident among those who died was 18:01-24:00 (47.0%) and among those who did not die the most common time of accident was 12:01-18:00 (43.9%) (p<0.001). Of those who died, the injury was most commonly caused by ≥4-wheeled vehicle (72.0%) but among those who survived the injury was most commonly caused by a motorcycle (59.8%) (p<0.001). Blunt force trauma was the most common cause of trauma among those who died (81.0%) and among those who did not die (91.4%) (p <0.001). The most common site of bodily injury among those who died was the head and neck (42.0%) and among those who did not die the most common site of injury was the extremities/pelvic girdle/external injury (66.8%) (p <0.001).

On logistic analysis, the time of day associated with the greatest chance of dying from injury was 18:01-24:00 (Odds Ratio (OR): 1.82; 95% CI: 1.29-2.57; p <0.001) and the time associated with the lowest chance of dying was 12:01-18:00

Table 1
Selected characteristics and their association with survival among study subjects.

Studied characteristics	Death (n = 100) Number (%)	Survival (n = 2677) Number (%)	p-value
Year of injury			0.516
2008	12 (12.0)	238 (8.9)	
2009	25 (25.0)	569 (21.3)	
2010	16 (16.0)	502 (18.8)	
2011	13 (13.0)	480 (17.9)	
2012	15 (15.0)	462 (17.3)	
2013	19 (19.0)	426 (15.9)	
Time of injury			< 0.001
00:01-06:00	9 (9.0)	140 (5.2)	
06:01-12:00	20 (20.0)	701 (26.2)	
12:01-18:00	24 (24.0)	1,175 (43.9)	
18:01-24:00	47 (47.0)	661 (24.7)	
Gender			0.112
Male	67 (67.0)	1,581 (59.1)	
Female	33 (33.0)	1,096 (40.9)	
Age group in years			< 0.001
<20	17 (17.0)	1,196 (44.7)	
20-39	26 (26.0)	634 (23.7)	
40-59	33 (33.0)	498 (18.6)	
≥60	24 (24.0)	349 (13)	
Type of road traffic accident			< 0.001
Hit by motorcycle	13 (13.0)	1,601 (59.8)	
Hit by vehicle with at least 4 wheels	72 (72.0)	809 (30.2)	
Other/unknown	15 (15.0)	267 (10)	
Mechanism of injury			< 0.001
Blunt force trauma	81 (81.0)	2,447 (91.4)	
Penetrating or blunt + penetrating trauma	19 (19.0)	230 (8.6)	
Body region of injury			< 0.001
Head or neck	42 (42.0)	477 (17.8)	
Face	2 (2.0)	84 (3.1)	
Chest	4 (4.0)	33 (1.2)	
Abdomen/pelvis	4 (4.0)	69 (2.6)	
Extremities/pelvic girdle/external	32 (32.0)	1,788 (66.8)	
Unknown	16 (16.0)	226 (8.4)	

(OR: 0.64; 95% CI: 0.43-0.95; p = 0.028). The age group associated with the greatest mortality was those aged ≥60 years (OR: 1.66; 95% CI: 1.13-2.44; p <0.009) and the age group associated with lowest mortality was those aged <20 years (OR: 0.44; 95% CI: 0.29-0.68; p <0.001). The type of vehicle associated with the greatest

mortality was ≥4-wheeled vehicles (OR: 2.61; 95% CI: 1.91-3.57; p <0.001) and the type of vehicle associated with the lowest mortality was a motorcycle (OR:0.23; 95% CI: 0.15-0.35; p <0.001). Having a penetrating or mixed blunt and penetrating injury was the type of injury associated with the greatest mortality (OR: 1.46; 95% CI: 1.09-1.94; p = 0.010) and blunt trauma was associated with the lowest mortality (OR:0.69; 95% CI: 0.52-0.91; p = 0.010). Having a head or neck injury was associated with the greatest mortality (OR: 1.88; 95% CI: 1.31-2.70; p <0.001) and having an extremity injury as associated with the lowest mortality (OR: 0.37; 95% CI: 0.26-0.54; p <0.001) (Fig 1).

DISCUSSION

In our study, we determined the factors significantly associated with hospital mortality in pedestrian traffic injury cases in southern Thailand during 2008-2013. In our study, the overall mortality rate was 3.6% of all pedestrian traffic injuries.

In this study, most accidents occurred during 12:00-18:00 but most deaths occurred during 18:00-24:00. Our results are similar to those of several studies that reported traffic accidents involving pedestrians tended to be more severe at night or when it was dark (Uttley and Fotios, 2017; Martínez-Ruiz *et al*,2019; Kim *et al*, 2017; Islam and Jones, 2014). However, studies from China (Zhang *et al*, 2014) and Iran (Sarikhani *et al*, 2017) reported pedestrian traffic mortality was greatest during morning and afternoon "rush hour".

In our study, pedestrian traffic mortality was higher with greater age. Our results are similar to those of other studies (Charters *et al*, 2018; Ghaem *et al*, 2017; Chandran *et al*, 2012; Onieva-García *et al* 2016). There may be several

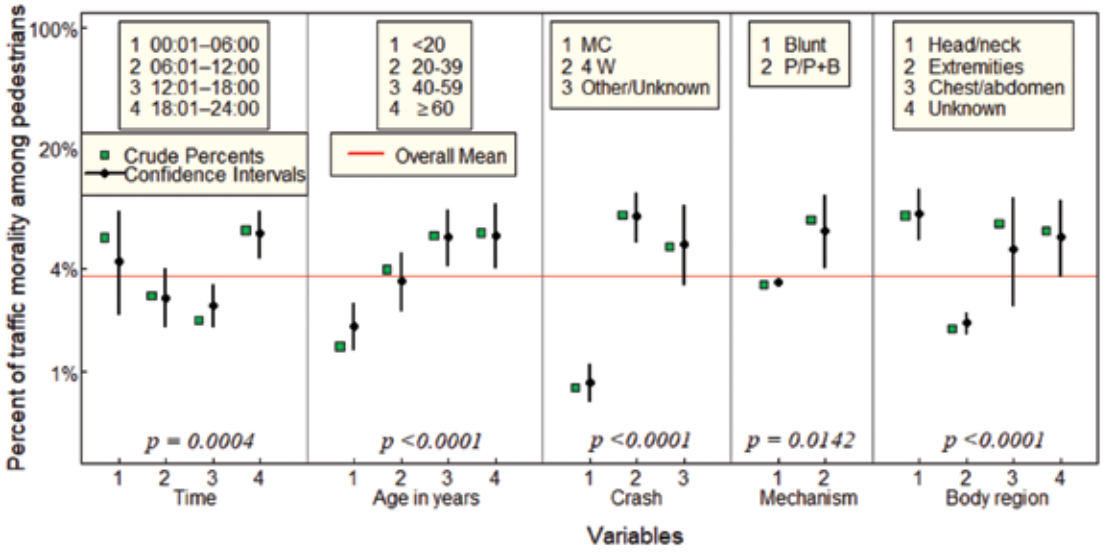

Fig 1-Associations between studied characteristics and mortality by logistic regression analysis.

MC: hit by motorcycle; 4 W: hit by vehicle having ≥4 wheels; P/P+B: penetrating injury or combined penetrating and blunt injury.

reasons for this finding. Older pedestrians have poorer vision, especially at night, less ability to move out of a dangerous situation quickly and may have poorer health prior to the injury making recovery more difficult.

In our study, more subjects struck by 4-wheeled than 2-wheeled vehicles died. Other studies have reported similar findings (Aziz *et al*, 2013; Kim *et al*, 2017; Qiriako, 2008). This could be because 4-wheeled vehicles may have been driven more quickly and have greater mass than 2-wheeled vehicles causing greater injury. A previous study reported for every 1% increase in vehicle speed the chances of dying in a pedestrian vehicle accident increased by 4% (WHO, 2018).

In our study, subjects who had a penetrating injury or the combination of a penetrating injury with blunt injury had a higher mortality than subjects who had a blunt injury only. Similar results have been reported by previous studies (Ehsaei *et al*, 2014; Peng *et al*, 2015; Alam El-Din *et al*, 2018). Penetrating injuries are more likely to cause more damage to bodily organs and more likely to cause exsanguinations, increasing risk of dying.

In our study, the injured body part associated with the greatest risk of dying was the head and neck, similar to the findings of previous studies (Sadeghi-Bazargani *et al*, 2018; Slesak *et al*, 2015; Ngo *et al*, 2012; Emara *et al*; 2015; Liu *et al*, 2016). A reason for this is there are more vital structures in the head and neck which when injured are more likely to cause a fatality.

A strength of this study was the data were gathered from 5 general hospitals over a 6-year period giving the study greater statistical power. This makes the results more easily generalizable to all of southern Thailand. There were some limitations of this study. First, the data used in this study were retrospective and based only on reported data. Another weakness is the lack of data regarding the environmental conditions at the time of the accident, such as the condition of the road, traffic warning signs, weather conditions, information about the vehicle, such as vehicle speed, the visual ability of the driver, the driving skill of the driver and whether they were intoxicated at the time of the accident.

In our study, the mortality rate of pedestrian traffic injuries in southern Thailand was 3.6%. The factors significantly associated with mortality were the time of the injury, the age of the pedestrian, the type of vehicle driven, the type of injury sustained and the bodily location of the injury. These factors need to be taken into consideration when developing programs to prevent pedestrian traffic mortality.

ACKNOWLEDGEMENTS

The authors thank those who participated in this study. This study was funded by the Graduate School, Prince of Songkla University, Thailand and partially funded by the Center for Excellence in Mathematics, Commission on Higher Education, Thailand. We are grateful to Professor Don McNeil for his helpful advice and suggestions and to Michael Guy Currie for helping improve the manuscript draft. We would like to express our gratitude to the Office of Disease Prevention and Control for permission to use their data.

REFERENCES

Alam El-Din ML, Nashy MR, Meshhal MT. Blunt vs. penetrating chest trauma in terms

of the outcome in Menoufia University Hospital. *Menoufia Med J* 2018; 3: 133-9.

Aziz HM, Ukkusuri SV, Hasan S. Exploring the determinants of pedestrian-vehicle crash severity in New York City. *Accid Anal Prev* 2013; 50: 1298-309.

Chandran A, Sousa TR, Guo Y, Bishai D, Pechansky F, Vida No Transito Evaluation Team. Road traffic deaths in Brazil: rising trends in pedestrian and motorcycle occupant deaths. *Traffic Inj Prev* 2012; 13 (Suppl 1): 11-6.

Charters KE, Gabbe BJ, Mitra B. Pedestrian traffic injury in Victoria, Australia. *Injury* 2018; 49: 256-60.

Damsere-Derry J, Ebel BE, Mock CN, Afukaar F, Donkor P. Pedestrians' injury patterns in Ghana. *Accid Anal Prev* 2010; 42: 1080-8.

Desapriya EB, Subzwari S, Sasges D, *et al*. Do light truck vehicles (LTV) impose greater risk of pedestrian injury than passenger cars? A meta-analysis and systematic review. *Traffic Inj Prev* 2010; 11: 48-56.

Dragu M, Salem A, Marinescu M. Forensic assessment of blunt thoracic trauma-correlations between pattern of injuries and trauma dynamics. *Rom J Leg Med* 2009; 17: 122-6.

Ehsaei MR, Sarreshtedar A, Ashraf H, Karimiani EG. Trauma mortality: using injury severity score (ISS) for survival prediction in east of Iran. *Razavi Int J Med* 2014; 2: e15189.

Emara AM, Greiw AS, Hassan NA. Pattern of road traffic injuries in patients admitted to Al-jlaa Hospital, Benghazi, Libya. *Tanta Med J* 2015; 43: 39-45.

Ghaem H, Soltani M, Yadollahi M, ValadBigi T, Fakherpour A. Epidemiology and outcome determinants of pedestrian injuries in a Level1 Trauma Center in Southern Iran; a cross-sectional study. *Bull Emerg Trauma* 2017; 5: 273-9.

Haleem K, Alluri P, Gan A. Analyzing pedestrian crash injury severity at signalized and non-signalized locations. *Accid Anal Prev* 2015; 81: 14-23.

Hasani J, Ahanchi NS, Rajabi A, Ghadiradeh M, Hashemi Naxari SS. An epidemiologic study of deceased pedestrians in road traffic accidents in Iran during 2012-2013. *Arch Trauma Res* 2017; 6: 63-8.

Islam S, Jones SL. Pedestrian at-fault crashes on rural and urban roadways in Alabama. *Accid Anal Prev* 2014; 72: 267-76.

Kim M, Kho S, Kim D. Hierarchical ordered model for injury severity of pedestrian crashes in South Korea. *J Safety Res* 2017; 61: 33-40.

Liu W, Su S, Qiu J, Zhang Y, Yin Z. Exploration of pedestrian head injuries-collision parameter relationships through a combination of retrospective analysis and finite element method. *Int J Environ Res Public Health* 2016; 13: 1250.

Martínez-Ruiz V, Valenzuela-Martínez M, Lardelli-Claret P, Molina-Soberanes D, Moreno-Roldán E, Jiménez-Mejías E. Factors related to the risk of pedestrian fatality after a crash in Spain, 1993-2013. *J Transp Health* 2019; 12: 279-89.

McWade CM, McWade MA, Quistberg DA, *et al*. Epidemiology and mapping of serious and fatal road traffic injuries in Guyana: results from a cross-sectional study. *Inj Prev* 2017; 23: 303-8.

Ngo AD, Rao C, Hua NP, Hoy DG, Trang KT, Hill PS. Road traffic related mortality in Vietnam: evidence for policy from a national sample mortality surveillance system. *BMC Public Health*. 2012; 12: 561.

Olszewski P, Szagala P, Wolański M, Zielińska A. Pedestrian fatality risk in accidents at unsignalized zebra crosswalks in Poland. *Accid Anal Prevention* 2015; 84: 83-91.

Onieva-García MA, Martínez-Ruiz V, Lardelli-Claret P, *et al*. Gender and age differences in components of traffic-related pedestrian death rates: exposure, risk of crash and fatality rate. *Inj Epidemiol* 2016; 3: 14.

Peng J, Wheeler K, Shi J. Groner JI, Haley KJ, Xiang H. Trauma with injury score of 75: are these unsurvivable injuries? *PLoS One* 2015; 10: e0134821.

Qirjako G, Burazeri G, Hysa B, Roshi E. Factors associated with fatal traffic accidents in Tirana, Albania: cross-sectional Study. *Croat Med J* 2008; 49: 734-40.

R Development Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing, 2015.

Roudsari BS, Mock CN, Kaufman R, Grossman D, Henary BY, Crandall J. Pedestrian crashes: higher injury severity and mortality rate for light truck vehicles compared with passenger vehicles. *Inj Prev* 2004; 10: 154-8.

Sadeghi-Bazargani H, Samadirad B, Moslemi F. A decade of road traffic fatalities among the elderly in North-West Iran. *BMC Public Health* 2018; 18: 111.

Sae-Tae N, Lim A, Kakchapati S, Ueranantasun A. Hospital reported factors associated with mortality among road traffic accident victims in southern Thailand. *Southeast Asian J Trop Med Public Health* 2018; 49: 717-26.

Saidi H, Mutiso BK, Ogengo J. Mortality after road traffic crashes in a system with limited trauma data capability. *J Trauma Manag Outcomes* 2014; 8: 4.

Sarikhani Y, Heydari ST, Gholamzadeh S, *et al*. Burden of traffic accidents among pedestrians of Fars province, southern Iran; estimate of years of life lost in a sample of Iranian population from 2009 to 2013. *Chin J Traumatol* 2017; 20: 259-63.

Schlottmann F, Tyson AF, Cairns BA, Varela C, Charles AG. Road traffic collisions in Malawi: Trends and patterns of mortality on scene. *Malawi Med J* 2017; 29: 301-5.

Slesak G, Inthalath S, Wilder-Smith A, Barennes H. Road traffic injuries in northern Laos: trends and risk factors of an underreported public health problem. *Trop Med Int Health* 2015; 20: 1578-87.

Tongkumchum P, McNeil D. Confidence intervals using contrasts for regression model. *Songklanakarin J Sci Technol* 2009; 31: 151-6.

Uttley J, Fotios S. The effect of ambient light condition on road traffic collisions involving pedestrians on pedestrian crossings. *Accid Anal Prev* 2017; 108: 189-200.

World Health Organization (WHO). Global status report road safety 2018, [cited 2019 Oct 13]. Available from: URL: https://www.who.int/publications/i/item/global-status-report-on-road-safety-2018

World Health Organization (WHO). Road safety institutional and legal assessment Thailand, 2015 [cited 2019 Oct 20]. Available from: URL: http://origin.searo.who.int/thailand/areas/rs-legal-eng11.pdf

Yadollahi M, Ghiassee A, Anver M, Ghaem H, Farahmand M. Analysis of Shahid Rajaee hospital administrative data on injuries resulting from car accidents in Shiraz, Iran: 2011-2014 data. *Chin J Traumatol* 2017; 20: 27-33.

Zhang G, Yau KK, Zhang X. Analyzing fault and severity in pedestrian-motor vehicle accidents in China. *Accid Anal Prev* 2014; 73: 141-50.