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REPORT

EXPERT REVIEW CARBON MONOXIDE (CO) RESPONSE PROTOCOL FOR MORWELL FIRES

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1 INTRODUCTION

The Department of Health (Victoria) has engaged Toxikos to provide an independent expert review of the carbon monoxide response (CMR) protocol for the management of potential impacts of the fire in the Hazelwood mine at Morwell in the Latrobe Valley. The CMR has been developed to guide the assessment and decision making for resulting actions for protecting public health in the event of elevated carbon monoxide (CO) levels in the environment arising from the ongoing fires at the coal mine in Morwell. The protocol is specific to the Latrobe Valley Coal Fires incident.

2 RESULTS

2.1 Health Effects of CO

The health effects of CO have been well studied and documented (ASTDR, 2013; NEPC, 2010; USEPA, 2000; WHO, 2000). The health effects experienced are related to carboxyhaemoglobin (COHb) levels in the blood which arise from inhalation of CO which displaces oxygen in the haemoglobin within the body. The binding affinity of CO for haemoglobin is 200 times that of oxygen. Formation of COHb decreases the oxygen carrying capacity of the blood and impairs the release of O_2 from haemoglobin for its utilisation in tissues (ASTDR, 2013). CO also decreases O_2 storage in muscle cells by binding to and displacing O_2 from myoglobin. Although all tissues are vulnerable to the effects of CO-induced hypoxic injury, those having the highest O_2 demand are particularly vulnerable, including the brain and heart.

Absorbed CO is eliminated from the body by exhalation and oxidative metabolism. The elimination half-time is about 100-300 minutes (ASTDR, 2013). The elimination half-life increases with age and is approximately 6% longer in males compared to females.

The extent of injury from acute CO exposure depends on the concentration and duration of exposure and the underlying health status of the exposed individual. The most commonly reported signs and symptoms of acute CO poisoning are due to effects on the central nervous system and the cardiovascular system.

In recent years the health effects of CO linked to ambient exposures have been well studied and reviewed by international agencies (NEPC, 2010; USEPA, 2000, 2009; WHO, 2000; OEHHA, 2000).

Most of the recent studies on the health effects of CO have been population-based epidemiological studies and have examined changes in mortality and morbidity, including hospital admissions and emergency room attendances. In addition, there have been a number of studies investigating the association between ambient CO and adverse birth outcomes, such as low birth weights. Australian studies have found associations between CO and cardiovascular hospital admissions and mortality, especially in the elderly for cardiac failure, myocardial infarction and ischemic heart disease with effects higher in the cool season. Associations have also been found with some birth outcomes, such as low birth weights. The results of these studies are consistent with the findings of international studies. The most vulnerable groups for these effects are people aged 65 years and older, as well as unborn foetuses.

Studies of hospital admissions and emergency department visits for ischemic heart disease (IHD) and congestive heart failure (CHF) provide the strongest evidence of ambient CO being associated with adverse cardiovascular disease (CVD) outcomes. The USEPA found that it was difficult to determine from this group of studies the extent to which CO is independently associated with CVD outcomes or

if CO is a marker for the effects of another traffic related pollutant or mix of pollutants (USEPA, 2009). On-road vehicle exhaust emissions are a nearly ubiquitous source of combustion pollutant mixtures that include CO and can be an important contributor to CO in near-road locations. Although this complicates the efforts to disentangle specific CO-related health effects, the evidence indicates that CO associations generally remain robust in co-pollutant models, are coherent with the effects demonstrated by controlled human exposure and animal toxicological studies, and supports a direct effect of short-term CO exposure on cardiovascular morbidity at ambient concentrations below the current national ambient air quality standards (NAAQS) in the US. The USEPA concluded that such direct effects are plausible considering that long-term, low concentration CO exposure could result in a COHb level approaching those used in controlled human exposure studies. There is also clear evidence from Australian studies of health effects below the current Australian standards in the AAQ NEPM.

2.1.1 Mortality

Studies investigating the links between short-term changes in ambient CO have been examined in time-series studies of daily exacerbations of pre-existing cardiovascular and respiratory disease and mortality and have yielded mixed results. A number of multi-city studies have been conducted in recent years (Dominici et al., 2003; Burnett et al., 2004; Samoli et al, 2007). The results of these multi-city studies reported comparable CO mortality risk estimates for total (non-accidental) mortality. The APHEA2 European multi-city study (Samoli et al., 2007) showed slightly higher estimates for cardiovascular mortality in single pollutant models. However, when examining potential confounding by co-pollutants these studies consistently showed that CO mortality risk estimates were reduced when NO_2 was included in the model (USEPA, 2009).

The results of several single city studies support the findings of the multi-city studies in that some evidence of a positive association was found for mortality upon short-term exposure to CO. Some studies conducted in the US, Canada and Europe have shown positive associations with cardiovascular mortality most strongly linked to exposure to CO (WHO, 2013; USEPA, 2009). However, many of the studies controlling for other pollutants reduced the effect estimate for CO and in some cases the association became non-significant (WHO, 2013). A study conducted in Melbourne found a significant positive association between a 5-day average 8-hour concentration of CO and cardiovascular deaths (all ages). The effects observed for CO were stronger in the warm season compared with the cool season, with significant associations found in the warm season for respiratory and all-cause mortality (Denison et al., 2000).

The USEPA concluded that the evidence from the recent multi- and single-city studies suggests that an association between short-term exposure to CO and mortality exists, but limited evidence is available to evaluate cause-specific mortality outcomes associated with CO exposure. It is unclear if CO is acting alone or as an indicator for other combustion related pollutants. Overall, the epidemiologic evidence is suggestive of a causal relationship between short-term exposure to environmentally relevant CO concentrations and mortality (USEPA, 2009).

2.1.2 Hospital admissions and emergency department attendances

There have been a number of studies that have found associations between hospital admissions and emergency department attendances and short-term exposure to CO. The associations were strongest for people with existing cardiovascular disease and the elderly (>65 years). Studies of hospital admissions and emergency department visits for ischemic heart disease (IHD) and congestive heart failure (CHF) provide the strongest evidence of ambient CO being associated with adverse cardiovascular outcomes.

Ballester et al. (2006) extended this research to include data from 14 Spanish cities for the period of 1995 to 1999. An average exposure period over lags 0-1 (ie the previous day's exposure) was analysed and for the combined estimates a 0.75ppm increase in 8-h max CO concentration was associated with a 1.77% (95% CI: 0.56–2.99) increase in all cardiovascular emergency hospital admissions and a larger increase of 3.57% (95% CI: 1.12–6.08) for heart disease admissions. These results persisted in two-pollutant models that included NO_2, O_3 and SO_2.

Barnett et al., (2006), examined associations between ambient CO concentrations and increased hospital admissions for various CVD outcomes. This study analysed data from 5 of the largest cities in Australia (Brisbane, Canberra, Melbourne, Perth, Sydney) and two New Zealand cities (Auckland, Christchurch) for the period 1998–2001. A time-stratified case-crossover design was employed and the age groups of 15–64 years and ≥ 65 years were analysed for the 0–1 lag period. Results were combined across cities using a random-effects meta-analysis. Pollutants considered were nitrogen dioxide, carbon monoxide (8-hr CO range of means 5 Australian cities 0.80-1.7ppm), daily measures of particles (PM_{10} and $PM_{2.5}$) and ozone. Where multiple pollutant associations were found, a matched case-control analysis was used to identify the most consistent association. The pooled estimates across all cities showed that a 0.9ppm increase in 8–h max CO concentration was associated with a 2.3% (95% CI: 0.7–3.2) increase in admissions for ischemic heart disease (IHD) and a 2.9% (95% CI: 0.6–4.1) increase in admissions for myocardial infarction (MI), but only among the elderly group (≥ 65 years). No association was found for admissions for stroke or arrhythmia in any age group. The combined estimates from the study also showed that an increase of 0.9ppm in the average 8-h max CO concentration over the current and previous day (lag 0-1) was associated with a 2.2% (95% CI: 0.9–3.8) increase in all CVD admissions, 2.8% (95% CI: 1.3–4.4) in all cardiac disease and 6% (95% CI: 3.5–8.5) in cardiac failure among those aged 65+ years. Among those aged 15–64 years there was a smaller increase in CVD admissions (1.0% [95% CI: 0.2–1.7]). In the elderly, all pollutants except O_3 were significantly associated with five categories of cardiovascular disease admissions. In matched analyses, CO had the most consistent association (Barnett et al., 2006).

Single city studies conducted in Australian cities have found consistent associations with hospital admissions and emergency department attendances for cardiovascular outcomes and CO (Jalaludin et al., 2007; Hinwood et al, 2006; Denison et al., 2001). The strongest effects are found in the elderly. Using a time-series approach, Jalaludin et al., (2007) examined the association between CO and emergency department attendances for single-day lags of 0, 1, 2, 3 and an average over lags 0 and 1. A 0.75ppm increase in 8-h max CO concentration for single-day lags 0 and 1 was associated with increases in attendances of 2.5% (95% CI: 1.6–3.5) and 1.4% (95% CI: 0.5–2.4) respectively. Based on an average over lags 0 and 1 (e.g., lag 0–1) there was an increase of 2.6% (95% CI: 1.5–3.6). There were positive increases of approximately 3% in CVD emergency department visits during the cool (May-October) period, but not the warm period (November-April). A 0.75ppm increase in 8-h max CO concentration (lag 0) was also associated with increases in IHD emergency department visits of 3.1% (95% CI: 1.3–4.9). No association was found between CO and stroke in the full year analysis. When the analyses were stratified by cool and warm periods a 0.75ppm increase in 8-h max CO concentration during the cool period was associated with a 3.8% (95% CI: 0.76– 6.94) increase in stroke emergency department visits.

Strong significant positive associations were found between CO and hospital admissions in Melbourne (Denison et al., 2001). The strongest associations were found for admissions for cardiovascular disease in the elderly (65+ years) and all ages groups, admissions for ischemic heart disease and admissions for asthma in the 0–14 year age group. The results of the seasonal analysis revealed that the associations were strongest in the cool season, although significant positive associations were also observed for respiratory admissions (65+ years and all ages), asthma

admissions (0–14 years) and cardiovascular admissions in the warm season. A 1ppm increase in 3-day average 8-hour CO was associated with a 3.29% and 2.72% increase in risk of admission for cardiovascular disease in the 65+ and all ages groups respectively. A 3.68% and 2.3% increase in admissions for ischemic heart disease was associated with a 1ppm increase in 1-hour maximum and 8-hour maximum CO respectively. The association between admissions for cardiovascular disease and ischemic heart disease and CO remained after controlling for other pollutants, however, the associations found with asthma and CO were removed after controlling for NO_2 and particles.

In Western Australia 263 children at high risk of developing asthma or atopy were recruited antenatally and all respiratory symptoms experienced by the children were recorded by their parents for five years and compared to ambient pollutant levels. Logistic regression models investigating relationships between individual air pollutants and respiratory symptoms showed significant associations between CO (8hr) and wheeze/rattle and runny/blocked nose (lag 5 and additive exposure over 5 days). Mean 8-hr CO was reported as 1.4ppm throughout the study period (Rodriguez et al. 2007).

2.1.3 Birth outcomes

CO has been associated with birth and developmental outcomes in international studies. The most compelling evidence for a CO-induced effect on birth and developmental outcomes is for preterm birth (PTB) and cardiac birth defects (USEPA, 2009). A number of studies have been conducted looking at varied outcomes, including PTB, birth defects, foetal growth (including low birth weight (LBW)), and infant mortality.

There is limited epidemiologic evidence that CO during early pregnancy (e.g., first month and first trimester) is associated with an increased risk of PTB. Studies to investigate the PTB outcome were conducted in California, and these reported consistent results whereby all studies reported a significant association with CO exposure during early pregnancy, and exposures were assigned from monitors within close proximity of the mother's residential address. Additional studies conducted outside of the U.S. provide supportive, though less consistent, evidence of an association between CO

Very few epidemiologic studies have examined the effects of CO on birth defects (USEPA, 2009). Two of these studies found maternal exposure to CO to be associated with an increased risk of cardiac birth defects. This insult to the heart is coherent with results of human clinical studies demonstrating that the heart is a target for CO effects. Animal toxicological studies provide additional evidence for such an insult to the heart, and reported transient cardio-megaly at birth after continuous in-utero CO exposure (60, 125, 250 and 500ppm CO), delayed myocardial electro-physiological maturation (150ppm CO), or systemic splenic immuno-compromise (75 or 150ppm CO). Toxicological studies have also shown that exogenous continuous *in utero* CO exposure (250ppm) induced teratogenicity in rodent offspring in a dose-dependent manner that was further exacerbated by dietary protein restriction (65ppm CO) or zinc depletion (500ppm CO). Toxicological studies of exogenous CO exposure over the duration of gestation have shown skeletal alterations (7 h/day, CO 250ppm) or limb deformities (24 h/day, CO 180ppm) in prenatally exposed offspring.

There is evidence of ambient CO exposure during pregnancy having a negative effect on foetal growth in epidemiologic studies (USEPA, 2009). In general, the reviewed studies reported small reductions in birth weight (ranging ~5–20g). Several studies examined various combinations of birth weight, LBW, and small for gestational age (SGA)/intrauterine growth restriction (IUGR) and inconsistent results are reported across these metrics. It should be noted that having a measurable,

even if small, change in a population is different than having an effect on a subset of susceptible births and increasing the risk of IUGR/LBW/SGA. It is difficult to conclude if CO is related to a small change in birth weight in all births across the population, or a marked effect in some subset of births.

Two studies in Australia have examined the association between birth outcomes and ambient CO. Mannes et al. (2005) estimated the average exposure during pregnancy to five common air pollutants for births in metropolitan Sydney between 1998 and 2000. The effects of pollutant exposure in the first, second, and third trimesters of pregnancy on risk of "small for gestational age" (SGA), and of pollutant exposure during pregnancy on birth weight were examined. Of the 138,056 singleton births; 9.7% of babies (13,402) were classified as SGA. In linear regression models carbon monoxide and nitrogen dioxide concentrations in the second and third trimesters had a statistically significant adverse effect on birth weight. For a 1ppm increase in mean carbon monoxide levels a reduction of 7 (95% CI, -5.0–19.0%) to 29 (95% CI, 7.0–51.0%) grams in birth weight was estimated.

2.1.4 Threshold for effect and sensitive groups

The results of epidemiological studies have found no evidence for a threshold below which adverse health effects in sensitive groups have not been observed after exposure to CO. The most sensitive groups to the effects of CO are people with existing cardiovascular disease including ischemic heart disease and the elderly.

The APHEA study (Samoli et al., 2007) performed a sensitivity analysis, which indicated an approximate 50–80% difference in CO risk estimates from a reasonable range of alternative models. In addition, the study examined the CO-mortality exposure-response relationship through a search of varying threshold points, and found only weak evidence of a CO threshold at 0.5 mg/m^3 (0.43ppm), but this result was complicated by the lowest 10% of the CO distribution for seven of the 19 cities examined being at or above 2 mg/m^3 (1.74ppm) (USEPA, 2009).

The ATSDR also concluded that there is no NOAEL for adverse effects from exposure to CO (ATSDR, 2012).

The groups that have been identified as being susceptible to the effects of CO are:

- Elderly
- People with existing cardiovascular disease
- Low socioeconomic groups
- Unborn foetus

2.2 Review of Guidelines for use in Emergency Management Situations

AEGLs

The Acute Emergency Guideline Levels (AEGLs) have been established by the USEPA to provide guidance in the event of an emergency situation. The background to the AEGLs is provided in the National Academy of Sciences (NAS) publication '*Acute Exposure Guideline Values for Selected Airborne Chemicals: Volume 8*'. These guidelines are used widely in the US by various agencies for response in emergency situations.

Three levels – AEGL-1, AEGL-2 and AEGL-3 – are developed for each of five exposure periods (10 and 30 min and 1, 4 and 8 hours) and are distinguished by varying severity of toxic effects (NAS, 2000).

The recommended exposure levels are applicable to the general population, including infants and children and other individuals who may be sensitive or susceptible.

The AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. However, the effects are not disabling and are transient and reversible on cessation of exposure.

AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects, or an impaired ability to escape.

AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life threatening health effects or death.

For CO no AEGL-1 was recommended because susceptible people may experience more serious effects (equivalent to AEGL-2) at concentrations that don't cause effects in the general population. Therefore the AEGL-2 has been developed to provide protection in emergency situations to sensitive groups within the population.

The AEGL-2 value is based on a COHb level of 4%. This is the level that ATSDR concludes that cardiac arrhythmia may occur in coronary artery disease patients (ATSDR, 2012). ATSDR also identify that neurobehavioural and cognitive effects do not occur until 5-20% COHb and a high risk of death does not occur until COHb levels reach 40-60% - at least 10 times higher than the basis of the AEGL-2.

The AEGL-2 values were based on effects in patients with coronary heart disease. At this exposure level, patients with coronary artery disease may experience a reduced time to onset of angina during physical exertion (Allred et al., 1989a,b, 1991). The AEGL-2 value is considered to be protective of neurotoxic effects in children. In the study by Klasner et al., (1998) acute neurotoxic effects, such as headache, dizziness, nausea and vomiting, were not observed until COHb levels reached a mean value of 7%.

2.2.1 Use of Ambient Air Quality Guidelines/Standards in Emergency Situations

Ambient air quality guidelines and standards, such as the NEPM standards and WHO guidelines are developed to protect the most sensitive individuals in a population for a lifetime (assumed 70 years) exposure. They have a high level of conservatism built into them and are not appropriate for use in emergency situations to determine whether evacuation is necessary.

2.3 Use of AEGL for Acute Assessment

The draft CMR protocol proposes the use of the AEGL-2 to guide the public health response. It is also proposed that the 1-hour AEGL-2 have an additional margin of safety added to obtain a value of 70 ppm. The use of AEGLs is considered to be appropriate for short-term acute exposure situations. The protocol and warning system outline in Figure 2 of the draft CMR is appropriate for this type of situation. It should be noted however that the 4% COHb is not a NOAEL – reversible impacts such as increases in cardiac arrhythmias may be seen in people with coronary heart disease (ATSDR, 2012). However, given that a NOAEL cannot be defined this health endpoint is considered conservative and is appropriate. AEGL documentation states that 4% COHb is unlikely to cause a significant increase in the frequency of exercise induced arrhythmias (NAS, 2000).

One issue identified with the draft CMR protocol is the time to a response (e.g., issuance of CHO health advice). The draft CMR protocol outlines the need to verify a 1-hour average concentration of CO greater than 70ppm, resulting in the DH assessment and CHO health advice being issued 2 hours after the initial identification of the exceedance of the 70 ppm 1-hour criteria. While this verification is prudent to ensure correct actions are taken, in cases where the CO concentrations are greater than 150 ppm in the initial 1-hour average measurement it would be advised that verification be undertaken as quickly as possible (e.g., undertake immediate spot sampling in the area of the exceedance) as adverse health effects would be expected during the period of initial reporting and the issuance of CHO health advice.

If the fires lead to prolonged periods (days to weeks) of consistently elevated exposure to CO, the AEGLs are not appropriate as they have been derived for an acute (short-term) emergency situation and do not protect against effects that may occur with long-term exposure at environmentally relevant concentrations, which are below the AEGL-2. If the fires do lead to days or weeks of elevated CO concentrations then the exposure and associated health effects become more sub-chronic than acute. If that situation arises then consideration should be given to the use of the LOAEL identified by the ASTDR 2.4% COHb.

3 CONCLUSION

For the acute emergency situation and current patterns of exposure in Morwell the proposed CMR protocol is considered appropriate. In cases where the CO concentrations are greater than 150 ppm in the initial 1-hour average measurement it would be advised that verification be undertaken as quickly as possible (e.g., undertake immediate spot sampling in the area of the exceedance) as adverse health effects would be expected during the period of initial reporting and the issuance of CHO health advice. If the exposure patterns change so that there is long term exposure (ie weeks to months) to high levels of CO (ie above 9 ppm (8hr) NEPM value and below the AEGL-2 27 ppm (8hr)) then the triggers may need to be revised to reflect sub-chronic rather than acute exposures.

4 REFERENCES

ATSDR (2012). Toxicological Profile for Carbon Monoxide. Agency for Toxic Substances and Disease Registry. June 2012

Ballester F; Rodriguez P; Iniguez C; Saez M; Daponte A; Galan I; Taracido M; Arribas F; Bellido J; Cirarda FB; Canada A; Guillen JJ; Guillen-Grima F; Lopez E; Perez-Hoyos S; Lertxundi A; Toro S (2006). Air pollution and cardiovascular admisisons association in Spain: results within the EMECAS project. J Epidemiol Community Health, 60: 328-336

Barnett, A. G., Williams, G. M., Schwartz, J., Best, T. L., Neller, A. H., Petroeschevsky, A. L. & Simpson, R. W. (2006) The Effects Of Air Pollution On Hospitalizations For Cardiovascular Disease In Elderly People In Australian And New Zealand Cities. Environmental Health Perspectives, 114, 1018-23.

Burnett, R. T., Stieb, D., Brook, J. R., Cakmak, S., Dales, R., Raizenne, M., Vincent, R. & Dann, T. (2004) Associations Between Short-Term Changes In Nitrogen Dioxide And Mortality In Canadian Cities Archives Of Environmental Health, 59, 228-36.

Dominici, F., Daniels, M., Mcdermott, A., Zeger, S. L. & Samet, J. M. (2003) Mortality Among Residents of 90 Cities. . In: Revised Analyses of Time-Series Studies Of Air Pollution And Health. Special Report. Boston, MA, Health Effects Institute.

Hinwood, A. L., De Klerk, N., Rodriguez, C., Jacoby, P., Runnion, T., Rye, P., Landau, L., Murray, F., Feldwick, M. & Spickett, J. (2006) The Relationship Between Changes In Daily Air Pollution and Hospitalizations In Perth, Australia 1992-1998: A Case-Crossover Study. International Journal of Environmental Health Research, 16, 27-46. 5

Jalaludin, B., Mannes, T., Morgan, G., Lincoln, D., Sheppeard, V. & Corbett, S. (2007) Impact of Ambient Air Pollution On Gestational Age Is Modified By Season In Sydney, Australia. Environmental Health: A Global Access Science Source, 6, 16.

Klasner, A.E., Smith, S.R., Thompson, M.W. and Scalzo, A.J. (1998) Carbon monoxide mass exposure in a pediatric population. Acad Emerg Med 5:992-996.

Mannes, T., Jalaludin, B., Morgan, G., Lincoln, D., Sheppeard, V. & Corbett, S. (2005) Impact of ambient air pollution on birth weight in Sydney, Australia. Occupational & Environmental Medicine, 62, 524-30.

NAS (2000) Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 8. Technical support document. National Academy of Science.

NEPC (2010). Review of the National Environment Protection (Ambient Air Quality) Measure: Discussion Paper Air Quality Standards. National Environmental Protection Council (NEPC).

OEHHA Office of Environmental Health Hazard Assessment (2000) Staff Report: Adequacy of California Ambient Air Quality Standards: Children's Environmental Health Protection Act. Sacramento, California Environmental Protection Agency.

Rodriguez, C., Tonkin, R., Heyworth, J., Kusel, M., De Klerk, N., Sly, P. D., Franklin, P., Runnion, T., Blockley, A., Landau, L. & Hinwood, A. L. (2007) The Relationship Between Outdoor Air Quality and

Respiratory Symptoms In Young Children. International Journal Of Environmental Health Research, 17, 30 351-60.

Samoli, E., Touloumi, G., Schwartz, J., Anderson, H. R., Schindler, C., Forsberg, B., Vigotti, M. A.,Vonk, J., Kosnik, M., Skorkovsky, J. & Katsouyanni, K. (2007) Short-Term Effects of Carbon Monoxide on Mortality: an Analysis Within The Aphea Project. Environmental Health Perspectives, 115, 1578-83.

United States Environmental Protection Agency (2000) Air Quality Criteria For Carbon Monoxide. USEPA (Ed.). Research Triangle Park, USEPA.

United States Environmental Protection Agency (2009) Integrated Science Assessment Of Particulate Matter. U.S. Environmental Protection Agency, Washington, DC,EPA/600/R-08/139F, 2009

WHO (2000). Air Quality Guidelines for Europe 2nd Edition. World Health Organisation Regional Office for Europe (WHO Regional Publications, European Series Number 91).