Bologna 5 giugno 2006
Giornata mondiale per l'ambiente

La qualità dell'aria in Emilia-Romagna

La valutazione degli effetti sanitari dell'inquinamento atmosferico

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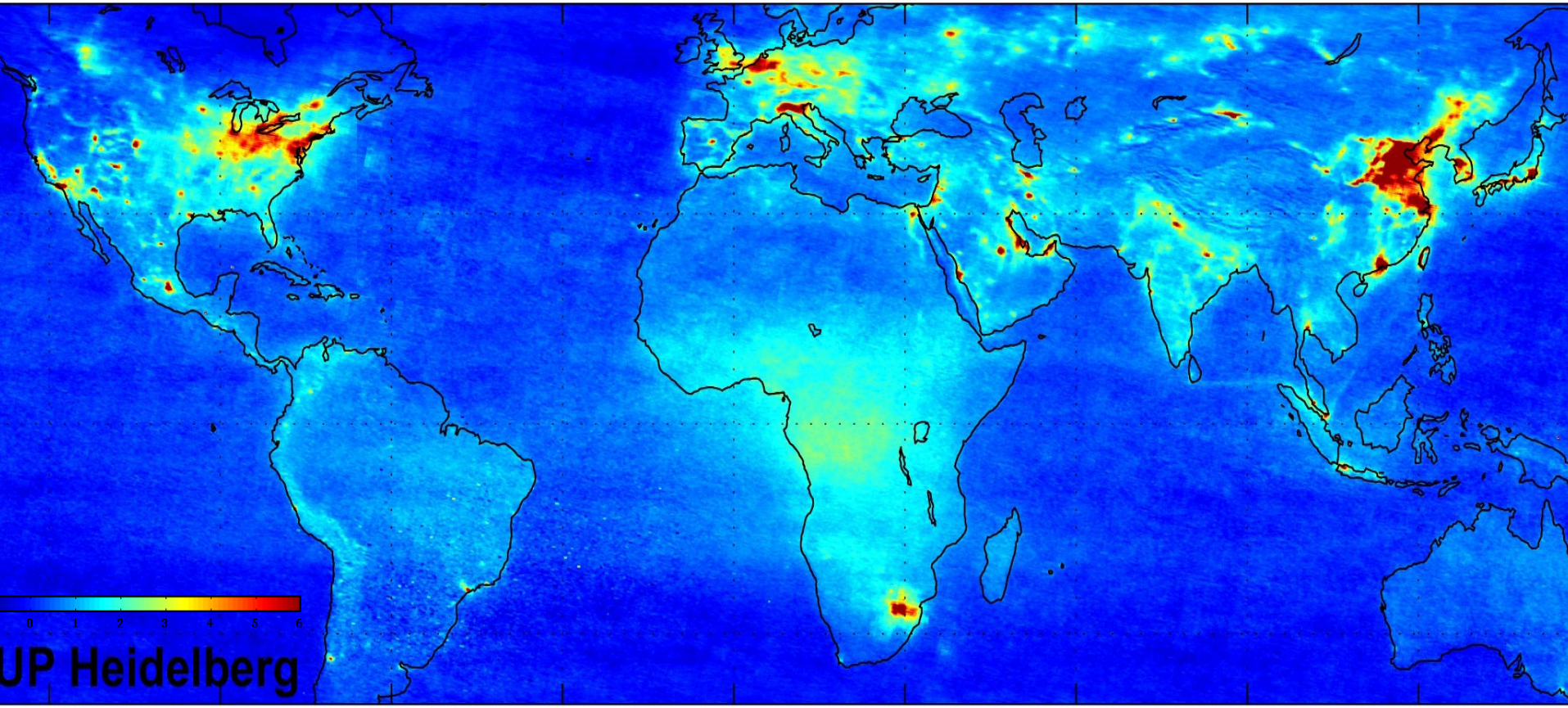
Regione Emilia-Romagna

SATELLITE SCIAMACHI

STRATO COLONNARE OSSIDI DI AZOTO



WHO launches early warning system against environmental risks to children's health

- 3 February 2004 -- This week, WHO is launching a comprehensive kit for monitoring and taking pre-emptive action against environmental dangers to children's health.
- **An estimated 25% of the global burden of disease is due to environmental risks, and 40% of that burden falls on children under five.**

Nigel Bruce, University of Liverpool
Publication: WHO - Indicators to improve children's environmental health

Inquinamento atmosferico

Miscela complessa,
Estremamente variabile di sostanze diverse, solide, liquide o gassose,
Molte delle quali potenzialmente dannose per la salute e per l'ambiente.
La stessa componente particolata (PM) è una miscela complessa di costituenti solidi e liquidi, composta da Sali inorganici e da composti organici

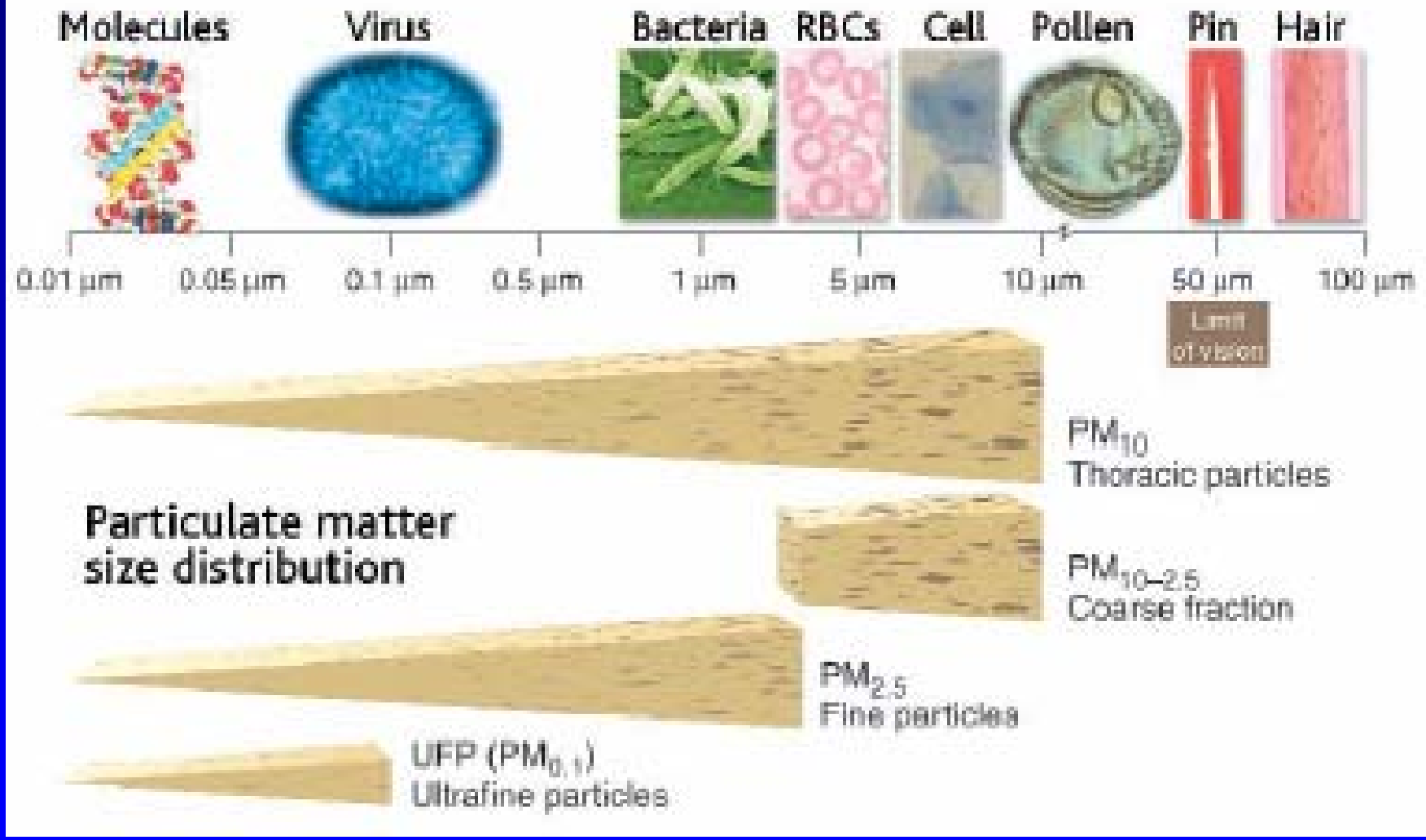
Air pollutant	Score	Health effects
Benzene	9	Carcinogenic, causes anaemia
1,3-Butadiene	8	Carcinogen
Polycyclic aromatic hydrocarbons (PAH)	8	Carcinogen, environmentally persistent
Arsenic and compounds	8	Carcinogen, environmentally persistent
Chromium and compounds	8	Carcinogen, affects respiratory system, inhalation can damage nose, throat, lungs, stomach and intestines, environmentally persistent. May lead to asthma, other allergic reactions, stomach upsets, ulcers, convulsions and kidne damage
Nickel and compounds	8	Carcinogen, can affect the respiratory system, environmentally persistent
Cadmium and compounds^	7	Carcinogen linked to prostate and kidney cancer in humans and also to lung and testicular cancer in animals. Smoke fr burning cadmium or cadmium oxide can, in severe cases, affect respiratory system, environmentally persistent
Dioxins and furans	7	Carcinogen, skin disease, environmentally persistent and bioaccumulates
Mercury	7	Can cause reproductive problems, environmentally persistent, bioaccumulates
Dichloromethane	5	Probable carcinogen, moderately persistent in the environment. High concentrations may cause unconsciousness and death. Exposure may irritate lungs, cause pulmonary oedema and irregular heartbeat. Long-term exposures at high level may damage the liver and brain
Formaldehyde	5	Carcinogen, irritates the skin, eye and respiratory system, and can exacerbate asthma
Styrene	5	Possible carcinogen
1,4-Dichlorobenzene	3	Probable carcinogen, moderately persistent in the environment
Tetrachloroethylene	3	Probable carcinogen
Manganese compounds	3	Can affect brain function, moderately persistent in the environment

A higher score indicates a more serious concern.

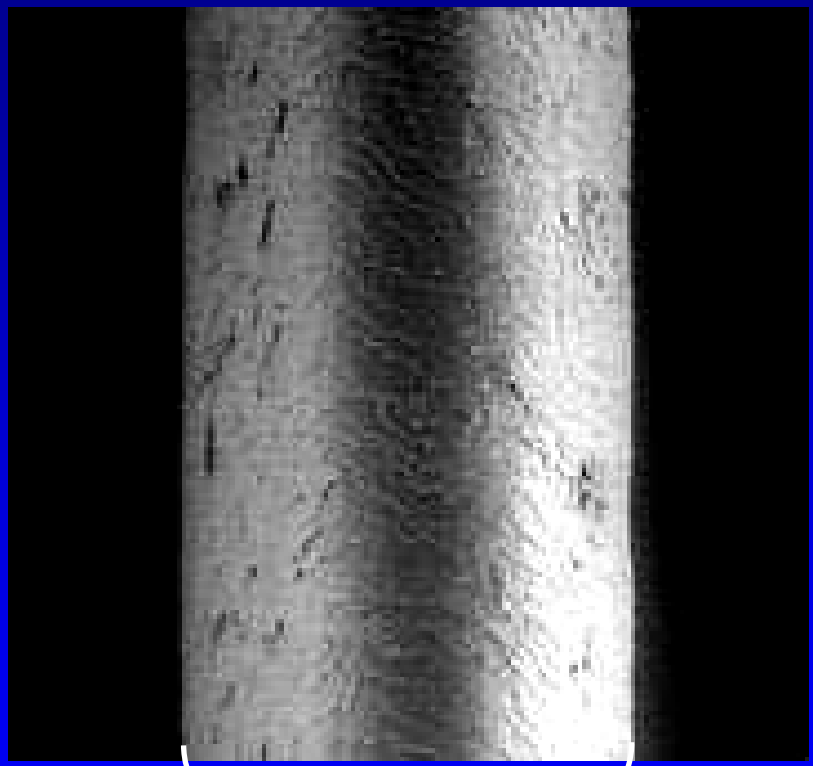
Source: EPAV (1999c).

DA CHE COSA E' COMPOSTO IL PARTICOLATO ?

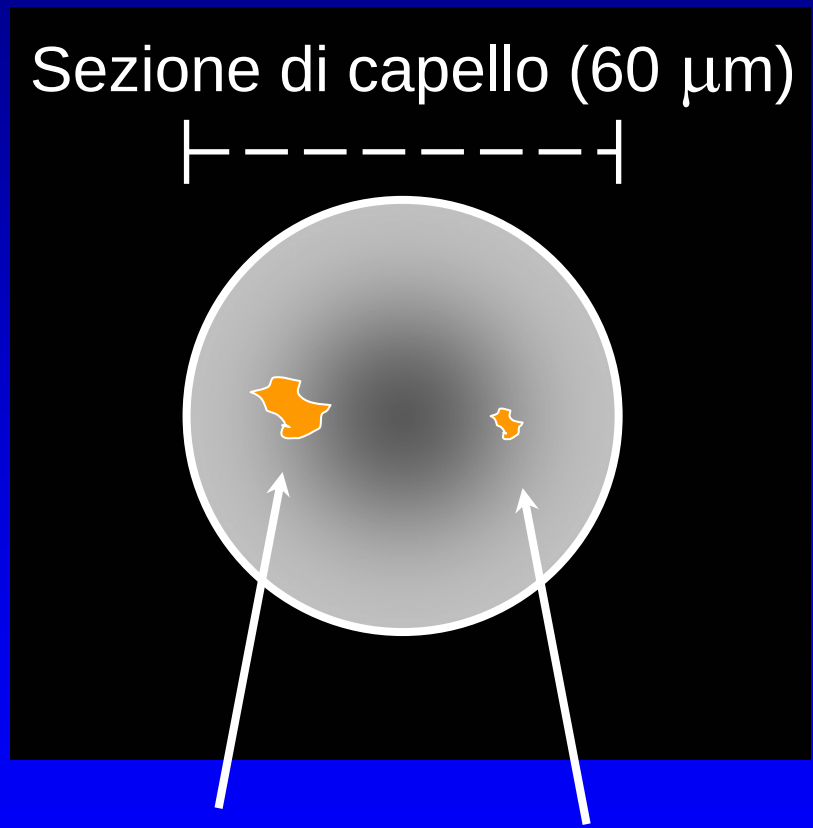
Miscela Complessa


Molecules
Virus
Bacteria
RBCs
Cell
Pollen
Pin
Hair
0.01 µm
0.05 µm
0.1 µm
0.5 µm
1 µm
5 µm
10 µm
50 µm
100 µm
Limit of vision
Particulate matter size distribution
PM10
Thoracic particles
PM10–2.5
Coarse fraction
PM2.5
Fine particles
UFP (PM0.1)
Ultrafine particles

QUANTO E' GRANDE IL PARTICOLATO ?



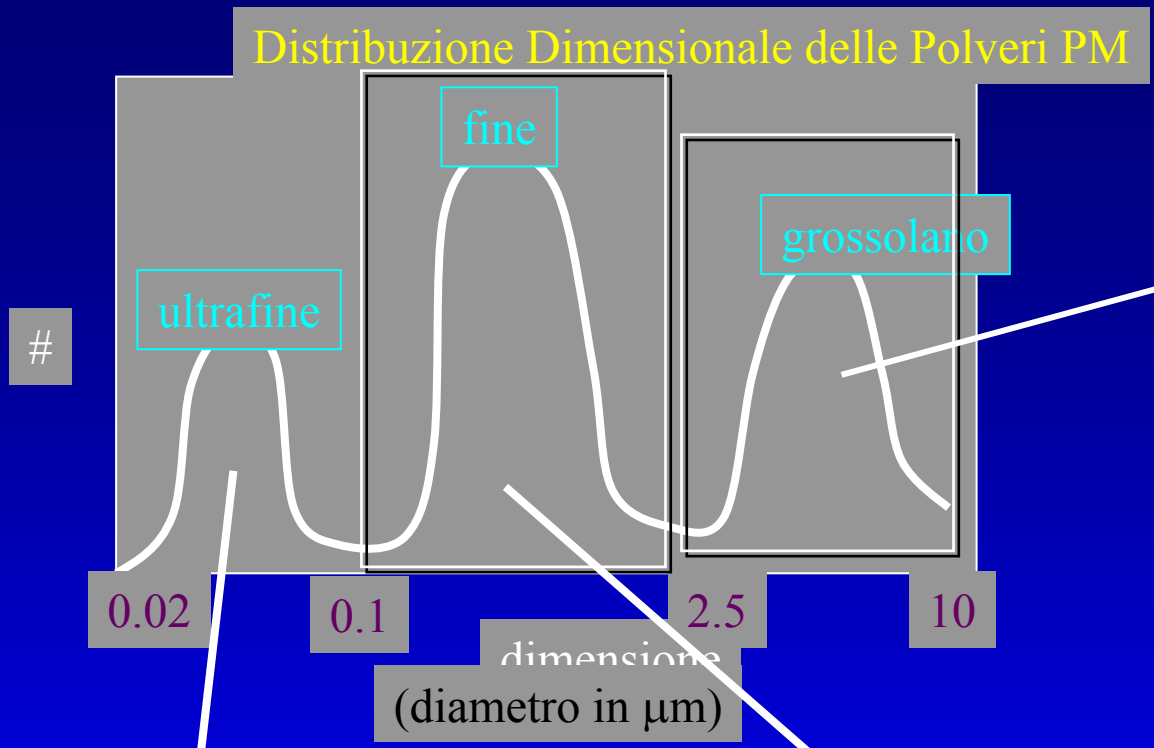
Capello Umano
(60 μm diametro)



PM_{10}
(10 μm)

$PM_{2.5}$
(2.5 μm)

Origine del PM



Processi meccanici

- polvere dalla terra
- strade, pneumatici
- freni auto
- attriti meccanici

Processo di condensazione

- reazioni atmosferiche
- combustione

Processo di accumulazione

- coagulazione
- condensazione delle particelle esistenti

√ combustione e reazioni atmosferiche

Che cosa serve sapere sull'inquinamento atmosferico per agire

Che cosa fa male (cause)

Che male fa (effetti)

Quando fa male (tempi)

Quanto fa male (misure e confronti)

Informazioni per l'azione

Come fa a far male (meccanismi d'azione)

Informazioni per il mondo scientifico

Pericolosità degli inquinanti: da che cosa dipende

- Quantità– (Dose assorbita)
- Tempo di esposizione (globale – gradiente)
- Caratteristiche chimiche:
  - della singola sostanza (Tossicità intrinseca)
  - della miscela (interazioni)
- Stato fisico (solido, liquido, gassoso)
- Dimensioni del particolato

Inquinamento atmosferico: quali effetti sulla salute

ACUTI

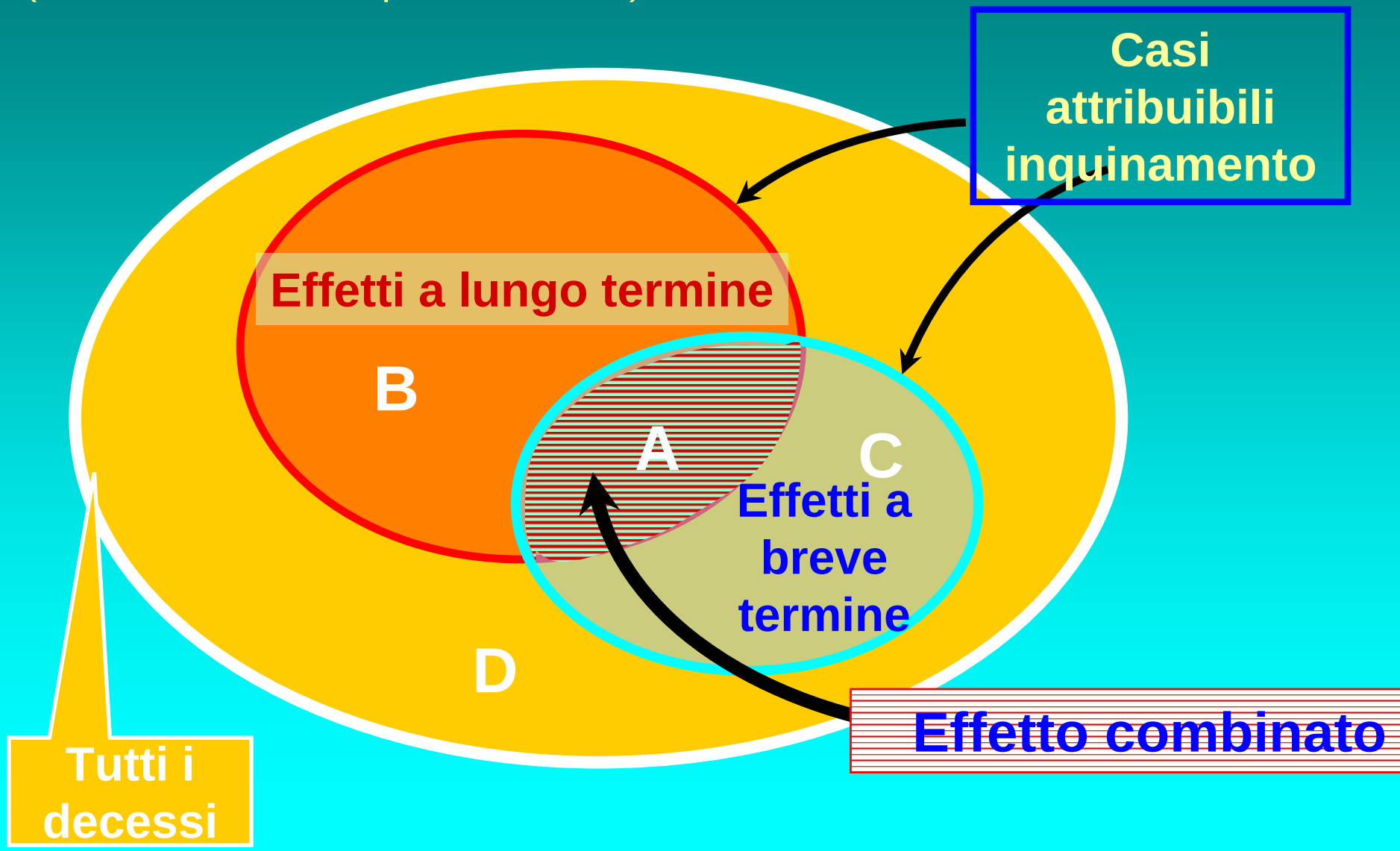
- mortalità generale
- mortalità cardiovascolare
- mortalità respiratoria
- ospedalizzazione per malattie respiratorie
- ospedalizzazione per malattie del sistema circolatorio

CRONICI

- mortalità generale
- mortalità cardiovascolare
- mortalità respiratoria
- tumore del polmone
- alcuni tumori infantili?
- sindromi neurolopsicogiche?
- patologie perinatali?

Effetti a lungo e breve termine

(Künzli et al, Am J Epidemiol 2001)



Inquinamento atmosferico: quando fa male. Effetti sulla salute e caratteristiche temporali

- Gli effetti acuti sono sensibili ai "valori di picco" degli inquinanti
- Gli effetti cronici (mortalità, parte dei ricoveri ospedalieri) sono determinati prevalentemente dalla concentrazione media degli inquinanti

“Piramide” degli effetti acuti

Adjusted mortality relative risk (RR) associated with a 10 ug/m^3 change in fine particles measuring less than 2.5 um in diameter

Cause of Mortality	Adjusted RR (95 % CI)* 1979-1983
All-cause	1.04 (1.01-1.08)
Cardiopulmonary	1.06 (1.02-1.10)
Lung cancer	1.08 (1.01-1.16)
All other cause	1.01 (0.97-1.05)

* Estimated and adjusted based on the baseline random-effects Cox proportional hazards model, controlling for age, sex, race smoking education marital status, body mass, alcohol consumption, occupational exposure, and diet. CI indicates confidence interval.

C. Arden Pope 3rd et al. JAMA 2002;287:1132-1141

Lo studio MISA 2

Epidemiologia e Prevenzione 2004;28(4-5) suppl: 1-100

9.100.000 abitanti

362.254 decessi

794.528 ricoveri

SO_2; NO_2; CO; PM_{10}; O_3.

15 città (Bologna, Ravenna); periodo: 1996-2002

Uno studio italiano conferma le ipotesi dell'Organizzazione mondiale della sanità, che aveva stimato in circa 3500 i morti da inquinamento atmosferico in otto grandi città italiane.

La ricerca italiana suffraga con dati empirici quelle che erano stime in gran parte basate su indagini condotte in altri Paesi. Ora dunque si può affermare con un alto grado di sicurezza che l'inquinamento atmosferico nelle aree urbane costituisce un fattore di rischio importante per la comunità in termini di morbosità, di riduzione della speranza di vita, di peggioramento della qualità della vita.

- In tutte le città **si è osservata una associazione statisticamente significativa fra ciascuno degli inquinanti studiati e ciascuno degli indicatori sanitari considerati**. Fa eccezione l'ozono, che è risultato associato con la mortalità totale e cardiovascolare e con i ricoveri per cause respiratorie;
- prendendo il PM10 (polveri fini) come parametro ambientale di riferimento, per ogni aumento di 10 ug/m3 di questo inquinante si è osservato nel complesso delle città considerate, un incremento nel giorno stesso o nel giorno successivo del 1.3% nella mortalità totale, 1.4% nella mortalità cardiovascolare, 2.1% nella mortalità respiratoria, 0.8% nei ricoveri per cause cardiovascolari, 1.4% nei ricoveri per cause respiratorie;

Lo studio italiano documenta **l'enorme rilevanza dell'inquinamento atmosferico per la salute** dei cittadini delle grandi città italiane. La relazione tra esposizione a inquinanti - specie le polveri fini - ed effetti sanitari, è presente anche per modesti livelli di inquinamento e coerente con un **modello "dose-risposta senza soglia"**: *con l'aumentare della concentrazione degli inquinanti, anche al di sotto dei livelli di attenzione e di allarme, aumenta il numero di persone affette da disturbi per la salute e non esiste una concentrazione al di sotto della quale non ci sono effetti sanitari.*

N° medio giornaliero di decessi per cause naturali e ds; media e ds delle concentrazioni medie giornaliere di NO2; variazione percentuale (vp) delle stime associate a un incremento del NO2 pari a 10 µg/m3 e IC al 95%.

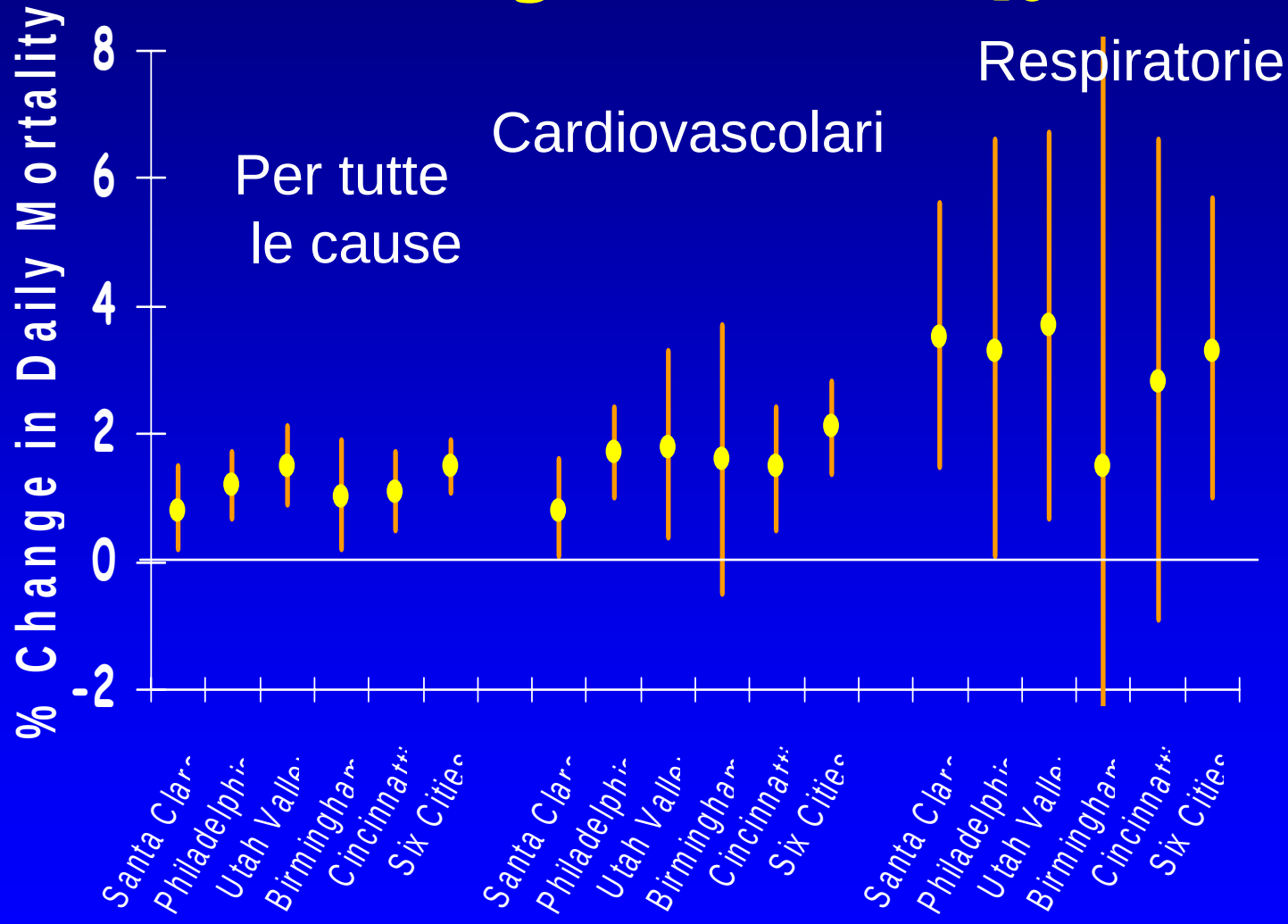
					intero anno		estate	
	Decessi medi giornalieri	ds	NO_2 medio µg/m³	ds	vp	ICr 95%	vp	ICr 95%
Bologna	11.6	3.5	60.6	17.7	0.69	0.14, 1.43	1.84	0.44, 3.34
Catania	7.3	3.0	50.3	12.9	0.49	-0.45, 1.15	1.13	-0.96, 2.69
Firenze	11.1	3.4	45.4	15.5	0.47	-0.39, 1.08	1.30	-0.55, 2.85
Genova	21.3	5.0	51.8	17.5	0.48	-0.09, 0.94	1.31	0.40, 2.17
Mestre-Venezia	4.6	2.2	39.0	19.0	0.56	-0.23, 1.30	1.69	-0.12, 3.53
Milano	29.1	6.1	61.2	24.8	0.70	0.29, 1.23	2.60	1.44, 3.99
Napoli	23.9	5.3	108.0	50.8	0.48	0.21, 0.73	1.00	0.33, 1.67
Palermo	14.3	4.7	54.4	16.2	0.58	-0.01, 1.19	1.85	0.68, 3.16
Pisa	2.2	1.5	40.6	12.5	0.60	-0.21, 1.42	1.68	-0.16, 3.63
Ravenna	3.7	1.9	47.7	18.0	0.53	-0.29, 1.18	1.34	-0.63, 2.98
Roma	58.3	8.9	70.0	14.3	0.92	0.41, 1.66	2.34	1.44, 3.32
Taranto	4.4	2.1	42.0	15.8	0.54	-0.31, 1.26	1.35	-0.57, 2.96
Torino	20.5	4.9	60.5	21.9	0.52	-0.07, 1.02	1.89	0.68, 3.32
Trieste*	5.6	2.4	31.5	18.2	0.55	-0.12, 1.17	1.44	0.10, 2.67
Verona	5.6	2.4	53.7	16.6	0.82	0.22, 1.99	2.10	0.52, 4.12

(*) I decessi si riferiscono al periodo in cui i dati di inquinamento erano disponibili

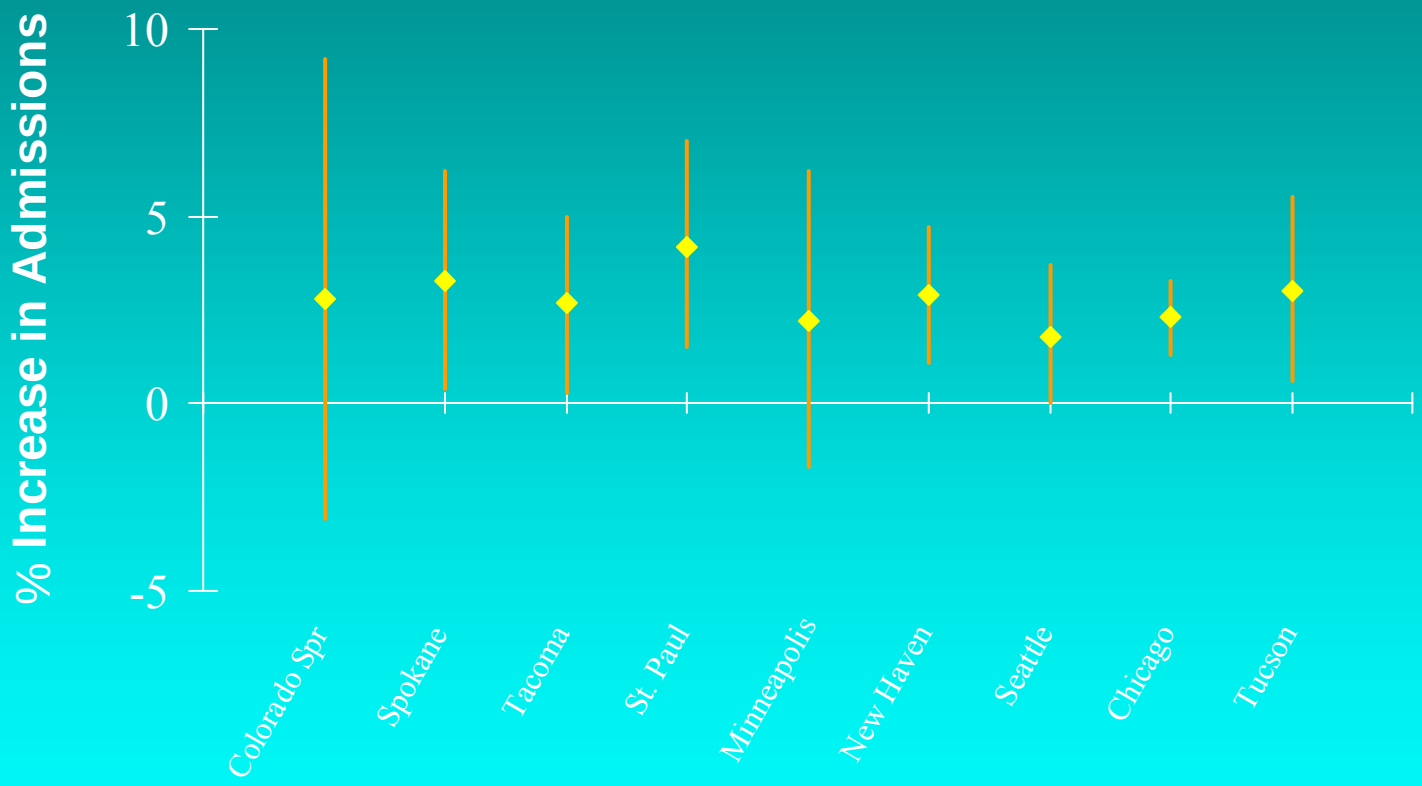
Stime del N° di decessi annui attribuibili alle concentrazioni di NO2 (i.c. 80%).

	NO_2			
	Stima metanalitica		Stima città-specifica a posteriori	
	Numero di decessi attribuibili	ICr 80%	Numero di decessi attribuibili	ICr 80%
Bologna	95	63, 128	109	57, 171
Catania	45	30, 60	36	3, 66
Firenze	55	37, 75	44	5, 77
Genova	136	91, 183	110	33, 176
Mestre-Venezia	19	12, 25	18	5, 30
Milano	249	166, 335	294	181, 425
Napoli	457	305, 616	368	236, 495
Palermo	99	65, 134	97	43, 154
Pisa	9	6, 13	9	3, 16
Ravenna	22	14, 29	19	4, 33
Roma	583	388, 787	885	518, 1320
Taranto	19	13, 26	18	4, 30
Torino	171	114, 230	149	56, 236
Trieste	14	9, 20	13	5, 22
Verona	39	26, 52	54	27, 90

Stima degli efetti ogni incremento di 10 $\mu g/m^3$ di PM_{10}



Particolato e ricoveri ospedalieri per cause cardiovascolari

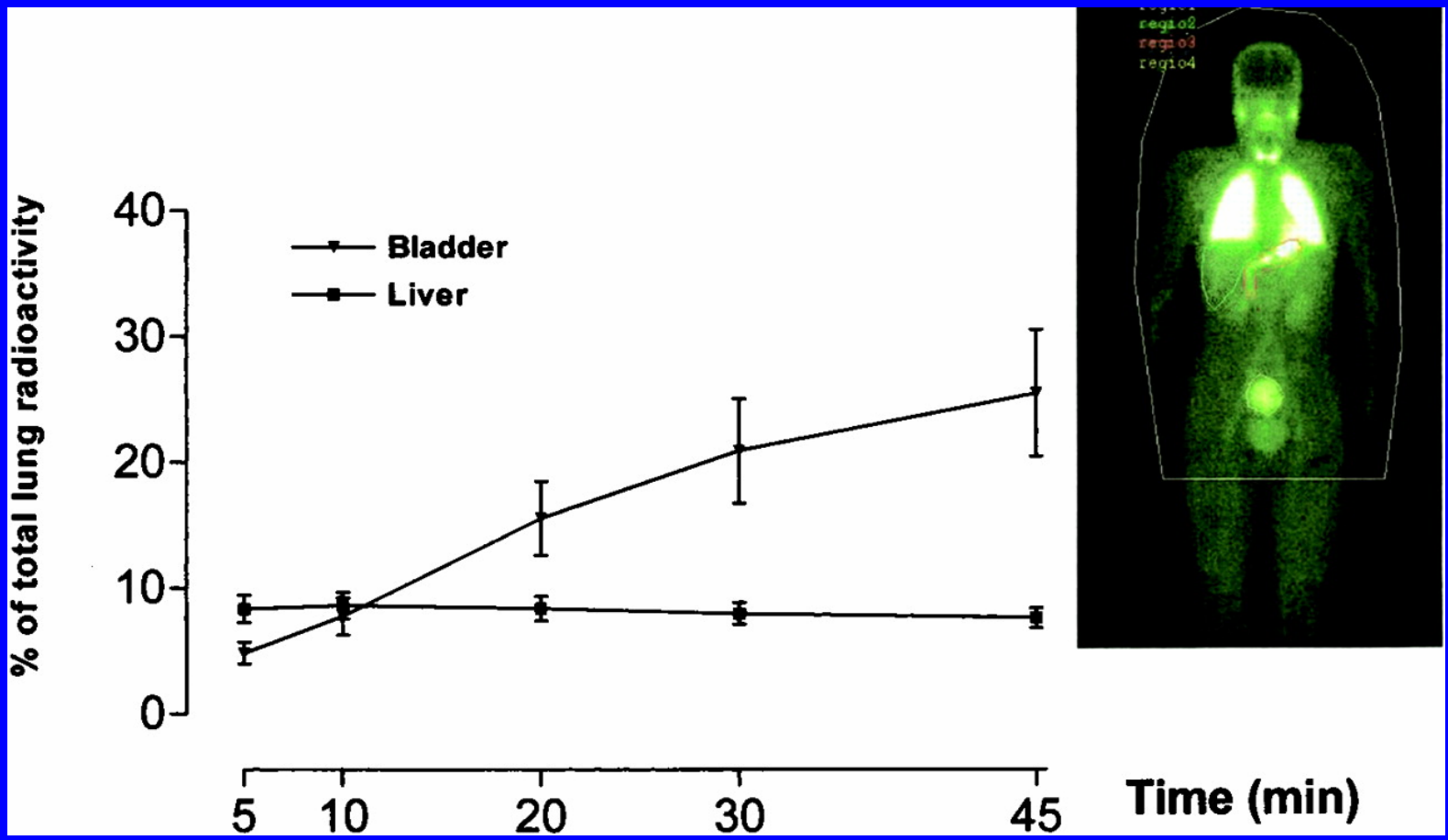


Schwartz, Epidemiology 1999

Gruppi di Popolazione Sensibili

- Bambini
- Anziani
- Persone con malattie preesistenti a carico dei polmoni o del cuore
- Persone che lavorano all'aperto, sportivi

Passage of Inhaled Particles Into the Blood Circulation in Humans. Nemmar et al. Circulation 2002;105:411.



The radioactivity recorded over the liver and bladder expressed as a percentage of the initial lung radioactivity

PM & Effects on the Circulatory System

Pulmonary inflammation and/or particles absorbed into the blood may:

Plasma viscosity

Plasma coagulability

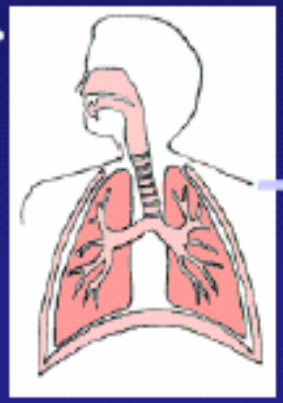
Thrombus formation

Cardiac ischemic events

(First proposed by Seaton A et al. Lancet 1995; 345:176-178)

PM - Potential Mechanisms of Action

PM ⇒



Pulmonary Inflammatio

Particle uptake
In blood

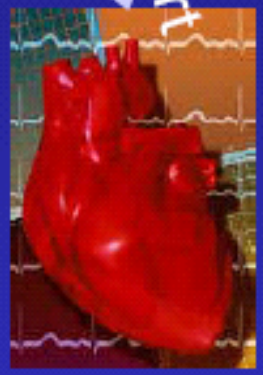
Direct transport

Systemic inflammation

Acute phase response

Autonomic stress respons

↑ C-reactive protein
Fibrinogen
Factor VII



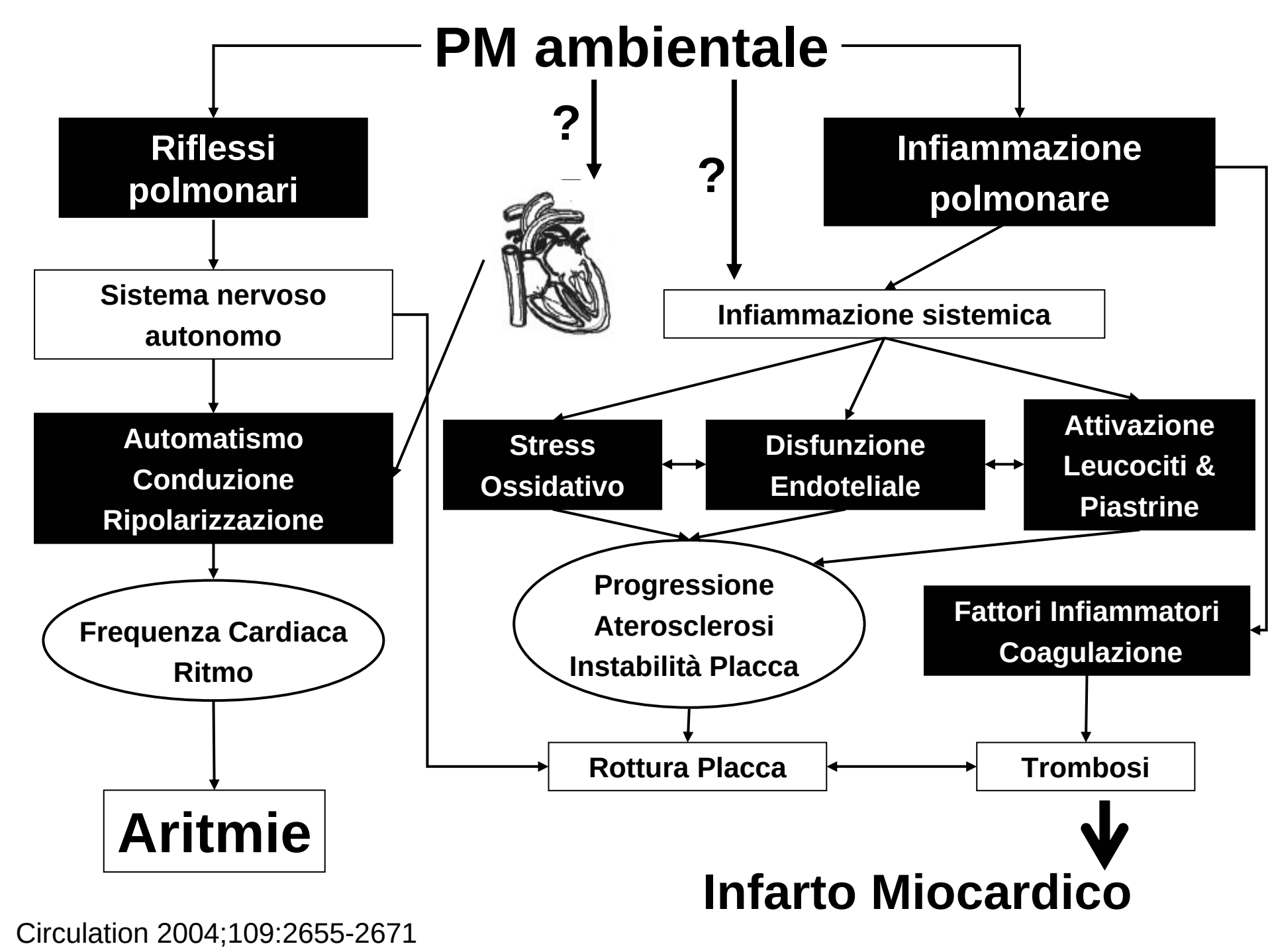
↑ Heart rate
↑ Blood pressure
↓ Heart rate variability

Rupture of
atherosclerotic
plaque

Thrombosis

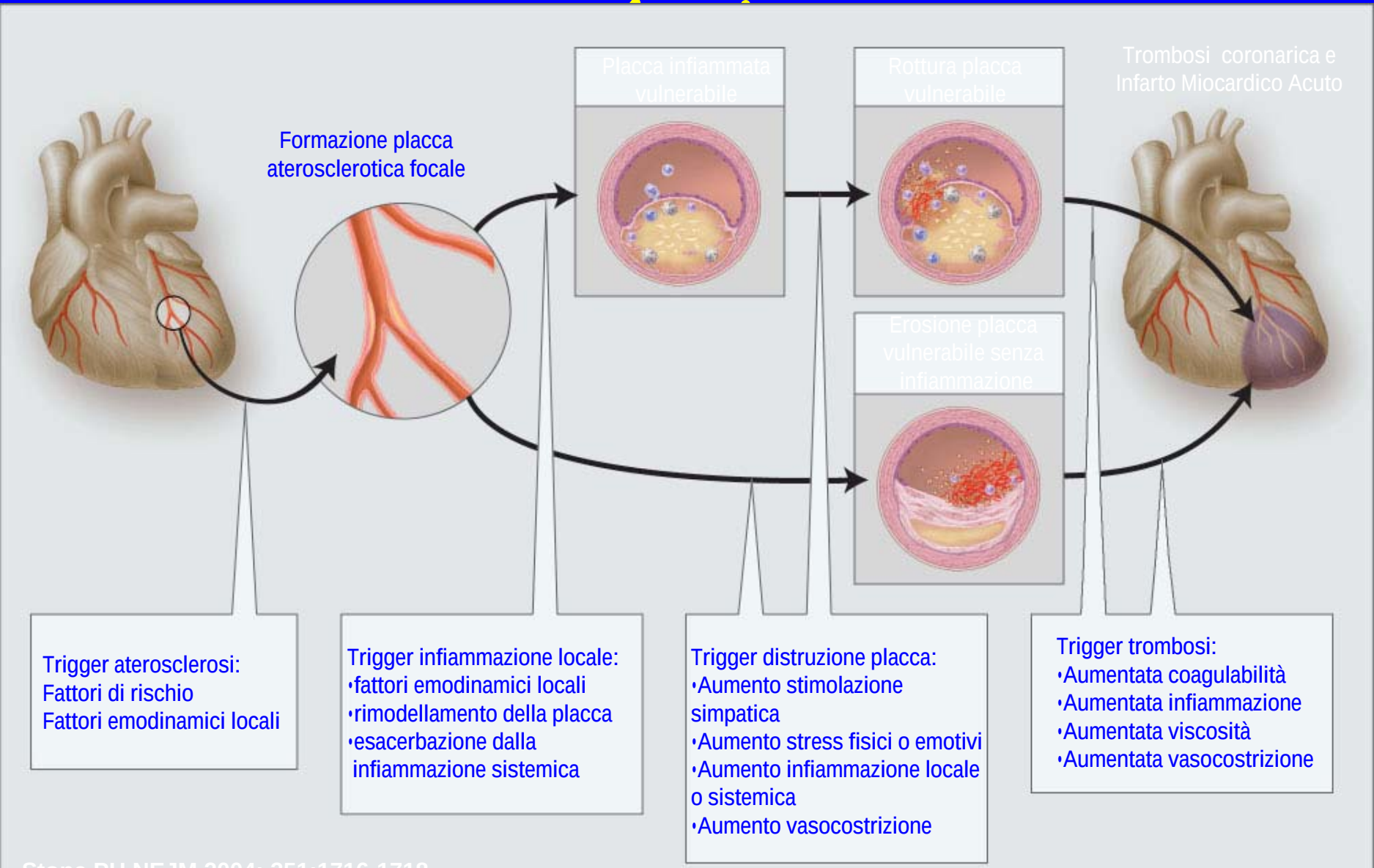
Cardiac
Ischemia

Arrhythm



Circulation 2004;109:2655-2671

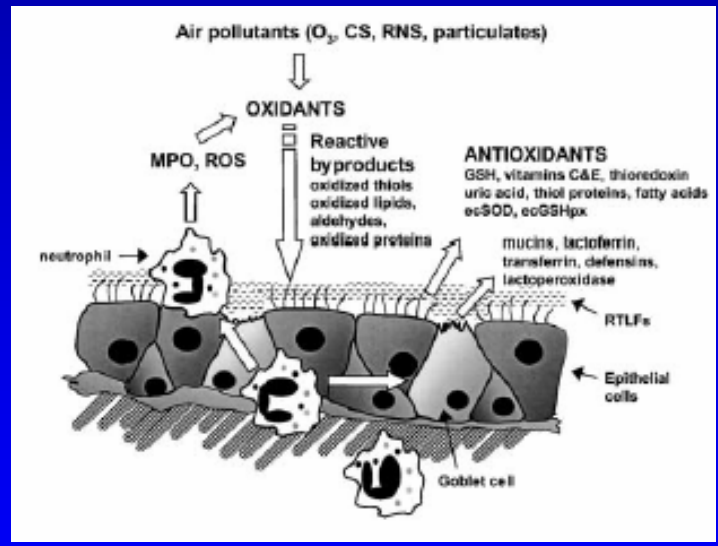
Trigger di Infarto Miocardico



Stone PH NEJM 2004: 351;1716-1718

Oxidant stress is a common theme in the action of a wide variety of air pollutants in inflammatory processes.

- Pollutants & oxidant stress:
  - Pollutants themselves
    - O_3, metals
  - Products from pollutants
    - Polyaromatic hydrocarbons & quinones from DEP and ETS
  - Oxidants from macrophages and granulocytes
    - Singlet oxygen, H_2O_2, superoxide



Cross, CE et al, American Journal of Respiratory and Critical Care Medicine Vol 166. pp. S44-S50, (2002)

Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution

C. Arden Pope III, PhD
Richard T. Burnett, PhD
Michael J. Thun, MD
Eugenia E. Calle, PhD
Daniel Krewski, PhD
Kazuhiko Ito, PhD
George D. Thurston, ScD

This presentation focuses on the most recent and largest prospective cohort study of long-term exposure to air pollution in the U.S.

JAMA, March 6, 2002—Vol 287, No. 9

Passage of Inhaled Particles Into the Blood Circulation in Humans

A. Nemmar, DVM, PhD; P.H.M. Hoet, PhD; B. Vanquickenborne, MD; D. Dinsdale, PhD; M. Thomeer, MD; M.F. Hoylaerts, PhD; H. Vanbilloen, PhD; L. Mortelmans, MD, PhD; B. Nemery, MD, PhD

Background—Pollution by particulates has been consistently associated with increased cardiovascular morbidity and mortality. However, the mechanisms responsible for these effects are not well-elucidated.

Methods and Results—To assess to what extent and how rapidly inhaled pollutant particles pass into the systemic circulation, we measured, in 5 healthy volunteers, the distribution of radioactivity after the inhalation of "Technegas," an aerosol consisting mainly of ultrafine ^{99m}Technetium-labeled carbon particles (<100 nm). Radioactivity was detected in blood already at 1 minute, reached a maximum between 10 and 20 minutes, and remained at this level up to 60 minutes. Thin layer chromatography of blood showed that in addition to a species corresponding to oxidized ^{99m}Tc, ie, pertechnetate, there was also a species corresponding to particle-bound ^{99m}Tc. Gamma camera images showed substantial radioactivity over the liver and other areas of the body.

Conclusions—We conclude that inhaled ^{99m}Tc-labeled ultrafine carbon particles pass rapidly into the systemic circulation, and this process could account for the well-established, but poorly understood, extrapulmonary effects of air pollution. (*Circulation*. 2002;105:411-414.)

Key Words: air pollution ■ particles ■ translocation ■ blood ■ lung

ORIGINAL ARTICLE

The procoagulant potential of environmental particles (PM_{10})

P S Gilmour, E R Morrison, M A Vickers, I Ford, C A Ludlam, M Greaves, K Donaldson, W MacNee

Occup Environ Med 2005;62:164–171. doi: 10.1136/oem.2004.014951

See end of article for authors' affiliations

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Accepted 22 September 2004

Background and Aims: Epidemiology studies have shown that cardiovascular (CV) disease is primarily responsible for the mortality associated with increased pulmonary environmental particle (PM_{10}) exposure. The mechanisms involved in PM_{10} mediated CV effects are unknown although changes in plasma viscosity and in the homoeostasis of blood coagulation have been implicated. It was hypothesised that PM_{10} exposure would result in an inflammatory response and enhance the activation of the extrinsic coagulation mechanisms in pulmonary and vascular cells in culture.

Methods: Primary human monocyte derived macrophages and human umbilical cord vein endothelial, human alveolar type II epithelial (A549), and human bronchial epithelial (16HBE) cells were tested for their inflammatory and procoagulant response to PM_{10} exposure. IL-8, tissue factor (TF), and tissue plasminogen activator (tPA) gene expression and protein release, and coagulation enhancing ability of culture media were determined 6 and 24 hours following exposure.

Results: The culture media from macrophages and 16HBE bronchial epithelial cells, but not A549 cells, exposed to PM_{10} had an enhanced ability to cause clotting. Furthermore, H_2O_2 also increased the clotting activity. Apoptosis was significantly increased in macrophages exposed to PM_{10} and LPS as shown by annexin V binding. TF gene expression was enhanced in macrophages exposed to PM_{10}, and HUVEC tissue factor and tPA gene and protein expression were inhibited.

Conclusions: These data indicate that PM_{10} has the ability to alter macrophage, epithelial, and endothelial cell function to favour blood coagulation via activation of the extrinsic pathway and inhibition of fibrinolysis pathways.

Inhalation of Fine Particulate Air Pollution and Ozone Causes Acute Arterial Vasoconstriction in Healthy Adults

Robert D. Brook, MD*; Jeffrey R. Brook, PhD*; Bruce Urch, MSc; Renaud Vincent, PhD; Sanjay Rajagopalan, MD*; Frances Silverman, PhD

Background—Fine particulate air pollution and ozone are associated with increased cardiovascular events. To help explain the mechanism behind these observations, we investigated the effect of air pollution exposure on vascular function.

Methods and Results—Twenty-five healthy adults underwent a randomized, double-blind, crossover study comparing the vascular response to the 2-hour inhalation of ≈150 $\mu g/m^3$ of concentrated ambient fine particles (CAP) plus ozone (120 ppb) versus the response to the inhalation of filtered air. High-resolution vascular ultrasonography was used to measure alterations in brachial artery diameter, endothelial-dependent flow-mediated dilatation (FMD) and endothelial-independent nitroglycerin-mediated dilatation (NMD). Exposure to CAP plus ozone caused a significant brachial artery vasoconstriction compared with filtered air inhalation (-0.09 ± 0.15 mm versus $+0.01\pm0.18$ mm, $P=0.03$). There were no significant differences in FMD ($+0.29\pm4.11\%$ versus $-0.03\pm6.63\%$, $P=0.88$), NMD ($+3.87\pm5.43\%$ versus $+3.46\pm7.92\%$, $P=0.83$), or blood pressure responses between exposures.

Conclusions—Short-term inhalation of fine particulate air pollution and ozone at concentrations that occur in the urban environment causes acute conduit artery vasoconstriction. (***Circulation***. **2002;105:1534-1536.**)

Key Words: vasculature ■ endothelin ■ endothelium ■ air pollution

REVIEW

Why cardiologists should be interested in air pollution

H C Routledge, J G Ayres, J N Townend

Heart 2003;89:1383–1388

Despite major improvements in air quality resulting from increasingly stringent legislation, there remains a strong association between daily mortality and current levels of air pollution. Growing epidemiological evidence suggests that many, perhaps the majority, of these deaths are caused by cardiovascular disease.

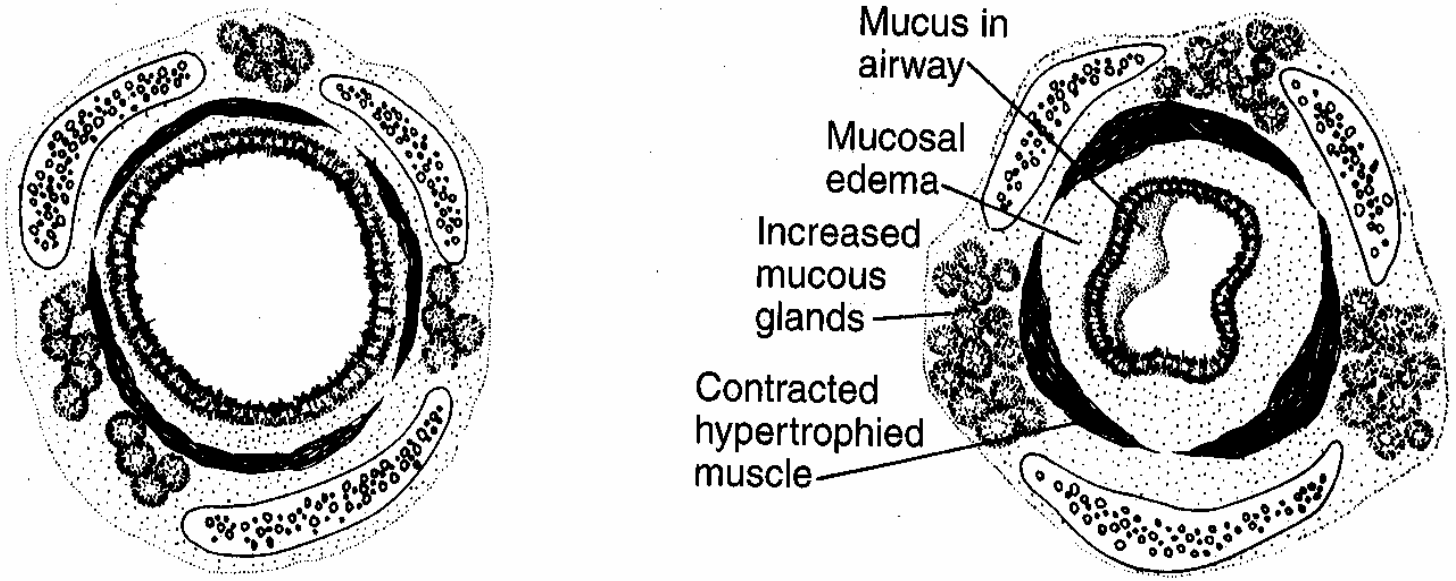
Urban air pollution is primarily derived from fossil fuel combustion and consists of both gaseous and particulate matter (PM) (table 1). Airborne particles are complex mixtures of elemental carbon, organic carbon compounds, and reactive components such as transition metals, metal oxides, acid condensates, sulfates, and nitrates. The particles believed to be most deleterious to health are

PM_{10} concentration would be associated with a 0.8% reduction in cardiovascular admissions.[27] A recent observation from Dublin suggests that these data may even underestimate the true benefit of achievable reductions in particulate pollution. A ban on coal sales in 1990 that reduced black smoke concentration by 35.6 $\mu g/m^3$ was associated with a 10.3% decrease in annual cardiovascular mortality.[28] In a similar intervention study, a 50% reduction in sulfur dioxide concentrations following legal restrictions on fuel oil sulfur in Hong Kong was immediately followed by a 2.4% reduction in cardiovascular deaths.[29]

Survival analysis data derived from cohort studies have also defined the population that is most susceptible to the cardiovascular effects of air pollution. The highest risk appears to be in people with pre-existing cardiac disease. Goldberg and colleagues,[30] for example, showed

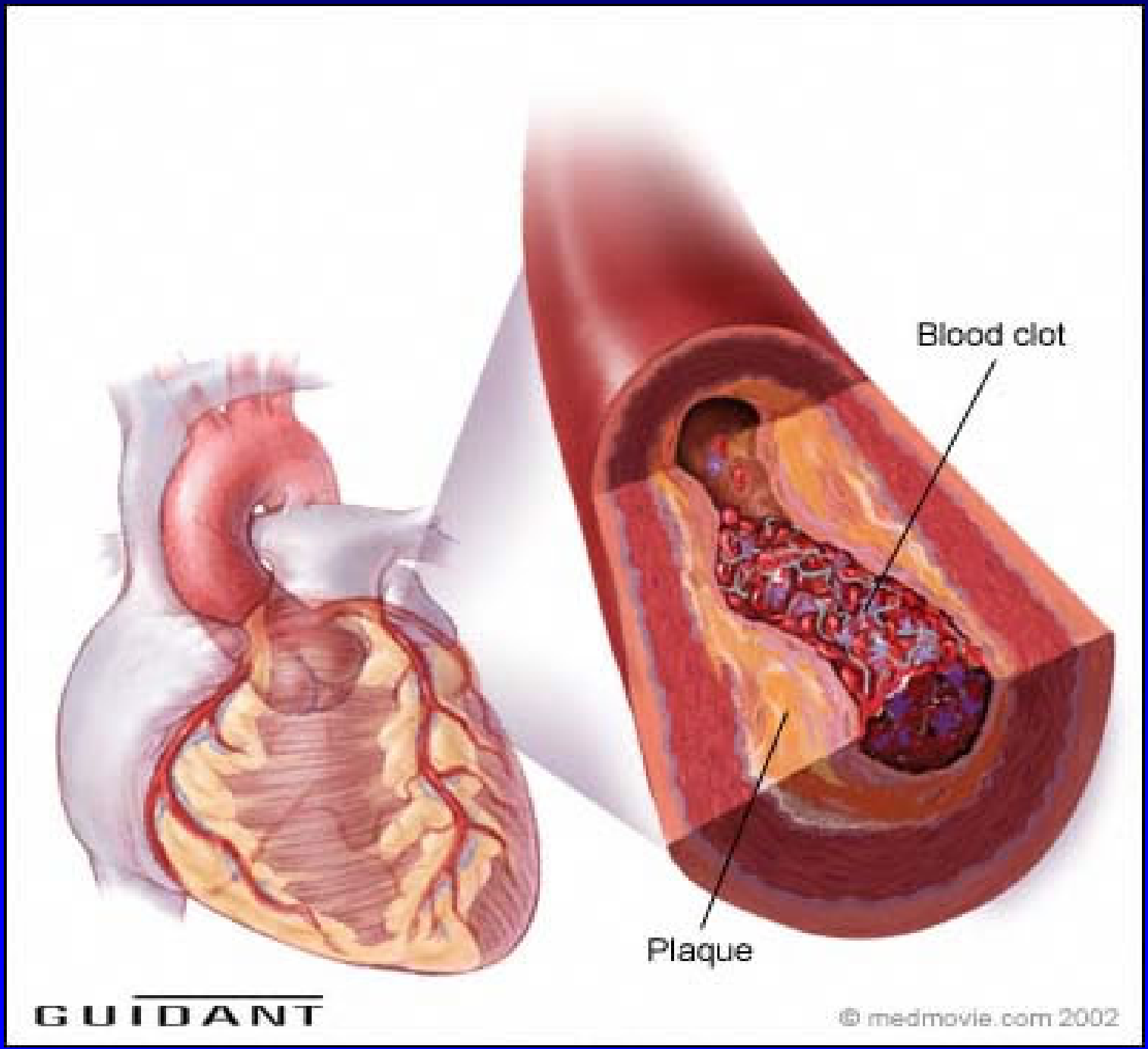
Hardhearted. The aortas of mice prone to atherosclerosis developed more lipid plaques (red) when they breathed concentrated particles for 5 months than did the same strain of mouse breathing clean air.

Asthma



Normal

Asthma

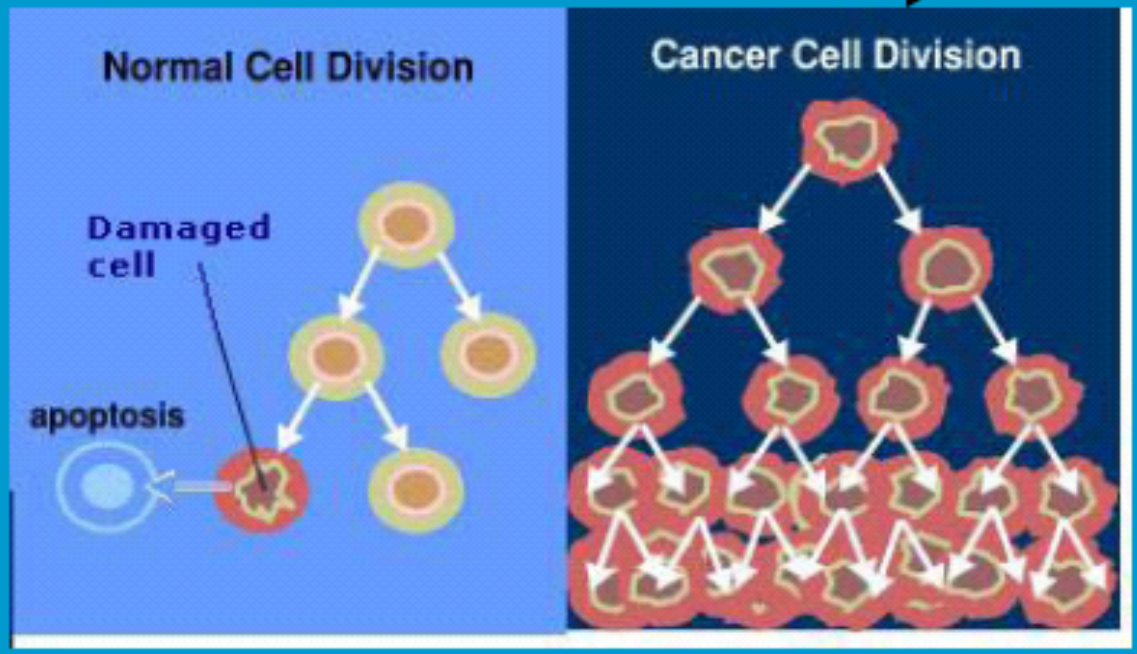

Blood clot
Plaque
GUIDANT
© medmovie.com 2002

Cancerogenesi

CRESCITA INCONTROLLATA...

Tessuto NORMALE

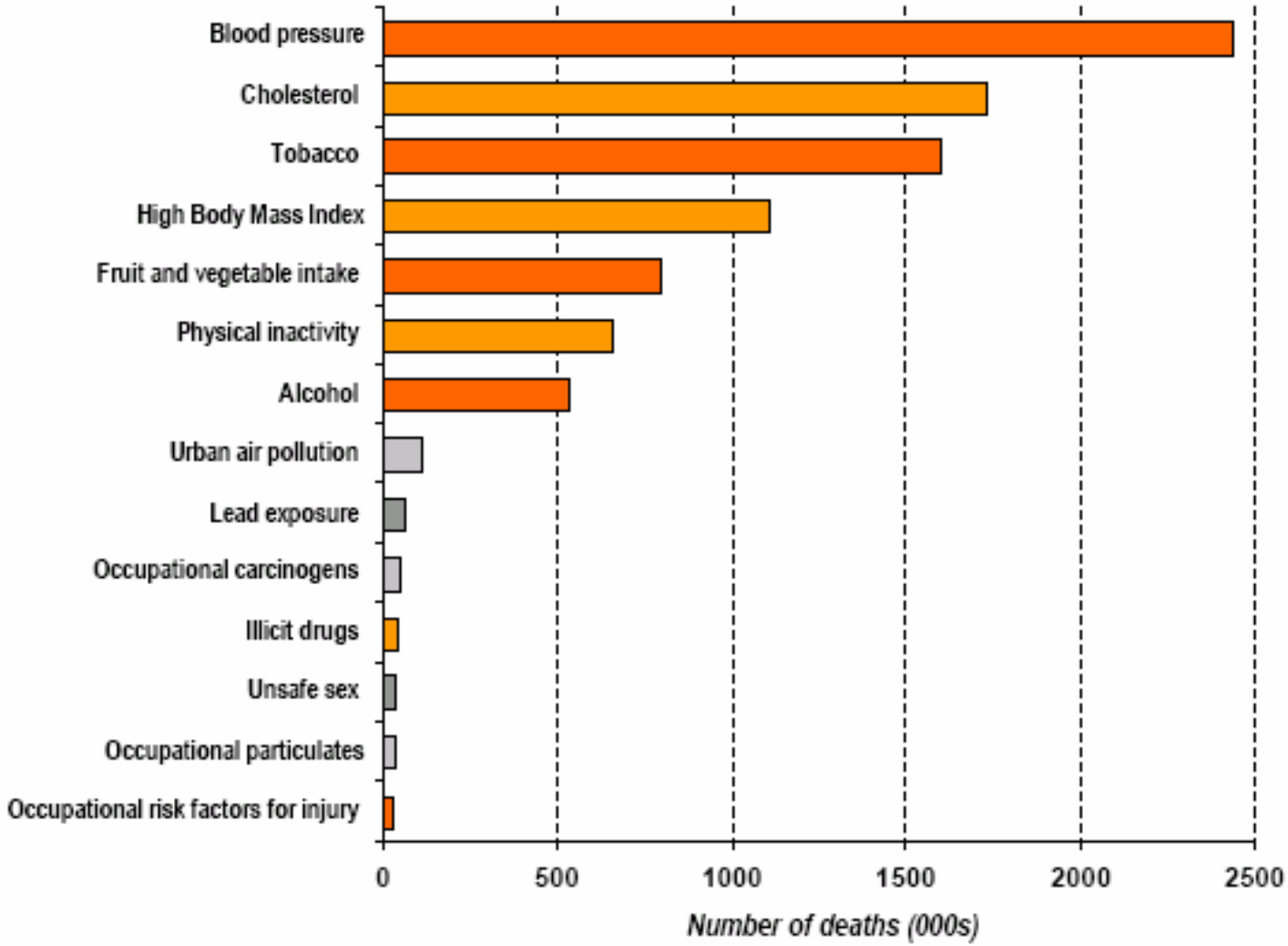
Tessuto TUMORALE



DI CELLULE ANORMALI...

EUROPE

Deaths in 2000 attributable to selected leading risk factors



World Health Organization (WHO) - *World Health Report* (WHR) 2002

Conclusioni

Gli effetti acuti e cronici dell'esposizione a inquinamento atmosferico nelle aree urbane sono ormai ben noti e caratterizzati.

Si tratta di effetti "deboli" ma la loro grande diffusione è responsabile di un numero di casi non trascurabile.

Gran parte degli effetti sanitari sono tecnicamente prevenibili.

Il problema di sanità pubblica è rilevante e deve essere affrontato da attori diversi.

La città italiana

Il cittadino si sposta all'interno del quartiere spontaneamente a piedi perché la forma e le dimensioni del quartiere e la distribuzione delle risorse sono state studiate proprio per questo

L'obesità è una risposta normale ad un ambiente anormale

Il Tema è:

L'ambiente obesogenico

L'ambiente costruito: la morfologia determina la funzione

Le trasformazioni avvenute nei centri abitati hanno modificato il comportamento della popolazione inducendo:

- **dipendenza dall'uso dell'automobile nella mobilità**: gli spostamenti connessi alla vita quotidiana (percorsi casa-scuola-lavoro-spesa-svago) sono prevalentemente compiuti con l'autoveicolo privato (e per lunghe distanze) comportamento che inibisce l'esercizio fisico;
- **disincentivazione della mobilità a piedi ed in bicicletta** (esercizio fisico): il camminare, conversare e giocare in strada sono state scoraggiate dai pericoli presenti, dall'angustia degli spazi, dal rumore e dalla forma degli edifici;
- ...

L’ambiente costruito: la morfologia determina la funzione il Design

Scars

Alta sicurezza = forte utilizzazione

L’ambiente costruito: la morfologia determina la funzione

L'ambiente costruito: la morfologia determina la funzione

la Pedonabilità

"I residenti in quartieri con molto verde, rispetto ai residenti in quartieri degradati, hanno probabilità di eseguire una significativa attività fisica tre volte più alta e hanno probabilità di essere sovrappeso o obesi del 40 % in meno."

Graffiti, greenery, and obesity in adults: secondary analysis of European cross sectional survey A. Ellaway, S. Macintyre and X. Bonnefoy

BMJ 2005;331;611-612

Piano regionale della prevenzione
Prevenzione delle recidive degli accidenti cardiovascolari acuti

OBIETTIVO 5
informazione ed educazione sulle malattie cardiovascolari

- Azione specifica: definire apposite istruzioni di comportamento per i soggetti cardiopatici in relazione alle condizioni di inquinamento atmosferico

- Raccordo con il sito "Liberiamo l'aria"

ONE HOUSE, ZERO ENERGY

Houses using less than 90 percent of the energy in typical homes are already technologically feasible. As energy prices rise and construction costs drop, they'll make increasing economic sense, too.