Firefighting and Death from Cardiovascular Causes
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Among the approximately 1.1 million firefighters in the United States (of whom about 70% are volunteers and 30% are paid career personnel), about 100 die each year in the line of duty.¹ With the exception of 2001, when 344 firefighters died as a result of the events of September 11 at the World Trade Center in New York City, the number of deaths per year has stayed relatively steady, even though the number of structural fires in the United States has been steadily decreasing. Nearly half of the deaths that occur while firefighters are on duty are related to cardiovascular events, and, in this issue of the Journal, Kales et al.² describe an innovative approach to improving our understanding of this risk. Their findings shed light on sudden cardiac events and their prevention, not just for this vital and revered profession, but also for those who may encounter some of the same risks at work or elsewhere.

Firefighting is a high-hazard job, and the work is at times extremely physically demanding. It involves heavy lifting and maneuvering in sometimes awkward and unstable positions while wearing heavy clothing and protective gear in a hot environment.³ In addition, exposure to carbon monoxide and particulate matter in the air is routine, and there is a highly variable risk of exposure to a broad array of other toxic chemicals generated from the smoke of burning materials.

It is not surprising that firefighters face an increased risk of illness and death due to cardiovascular disease during periods of intense physical and even psychological stress at work. However, numerous mortality studies, some of which have shown evidence of an increased risk of some cancers (e.g., brain tumors and leukemia) and nonmalignant respiratory diseases, have not shown any consistent evidence of an increased risk of death from cardiovascular disease.³-⁵ Why not? First, firefighters as a group quintessentially show a “healthy worker effect.” That is, by the very nature of their generally high levels of fitness and health (mandated for all entry-level career firefighters and sometimes required for volunteers), they would be expected to have a lower risk of death (particularly due to cardiac events) than the general population. And they do — on average, a firefighter’s risk of dying from coronary heart disease is about 90% (standardized mortality ratio, 0.9) that of others in the general population. Thus, firefighters overall may not have an excess risk of dying from heart disease, or if they do, the excess risk is small. There is some suggestion of the latter, since many working industrial populations have an even lower risk of dying from coronary heart disease (standardized mortality ratio, 0.8) than firefighters as compared with the general population. One would expect firefighters to fare at least as well. Second, the overall mortality remains a definitive but crude measure of the relationship between exposure hazards and health, and most importantly, of the benefits of prevention. So, even if firefighters have little or no excess risk of death due to cardiovascular disease, there are reasons to both understand and try to prevent the cardiovascular events that do occur, including those that occur on the job.

Kales and colleagues build on the observation that cardiovascular events that occur while firefighters are on duty appear to cluster around specific activities (e.g., fire suppression and emergency response) and on their own earlier case–control study suggesting that specific duties are associated with deaths due to coronary heart disease.⁶ In this study, they reviewed data on all deaths that occurred while firefighters were on
duty over an 11-year period (1144 deaths). With
the use of all available records, they independ-
ently classified these deaths according to cause
and firefighting duty at the time of death. What
is most compelling about this study is their effort
to quantify the excess risk of dying during spe-
cific firefighting duties. They calculated odds
ratios for death by comparing five specific emer-
gency duties (e.g., fire suppression and alarm re-
sponse) with nonemergency duties. These com-
parisons were based on three separate sources of
data indicating how much time firefighters typ-
ically spend in each of these activities. Measures
of the distribution of duty time are variable and
imprecise, but the findings of Kales et al. are suf-
fi ciently large (e.g., the odds of death from coro-
mary heart disease during fire suppression were
10 to 100 times as high as during nonemergency
duties) to overcome concern that the direction
of the results is wrong because of misclassification
errors. They overcome at least part of the effect
of the selection of healthy workers by making com-
parisons among groups of firefighters. In fact,
the selection process according to health that may
keep firefighters out of emergency duties with-
out keeping them out of work may, if anything,
lead to an underestimation of their odds of death
from coronary heart disease.

The authors have not set out to show nor have
they shown an overall increased risk of death from
coronary heart disease among firefighters. How-
ever, they have convincingly shown that such an
event is far more likely to occur during specific
duties — dramatically so during fire suppression,
but also during alarm response and return and
physical training. When healthy workers die at
work of “natural” causes, their deaths are predom-
antly from sudden cardiac events. The finding
that these events might cluster around or be trig-
gered by specific duties is also not new, so this
pattern of increased deaths during emergency du-
ties should not surprise us but should inform us.

Numerous studies over several decades have
shown the role of heavy exertion — from snow
shoveling to recreational exercise — in triggering
sudden myocardial events and the protective role
of regular exercise in mitigating them.7-9 This par-
adox — that regular exertion is good even though
an episode may trigger an adverse event — is not
a reason to dismiss these findings, but it should
call for caution. Relative measures of association
may be high because the incidence rate in the
risk period (emergency situations) is high or be-
cause the incidence rate in the reference period
(nonemergency situations) is low, or both. A ph ys-
cal fitness program may lower the incidence rate
during the reference period (nonemergency du-
ties) more than during the risk period, and thus
it may increase the odds ratios for death during
the risk period, even in a situation in which the
overall mortality due to cardiovascular diseases
is reduced. The evaluation of a preventive pro-
gram — a step that naturally follows these findings —
should take the overall mortality into consid er-
ation.

Firefighters have episodic exposure to ex-
treme levels of physical exertion, and they face
occupational hazards that may add to or amplify
their risk of death due to cardiovascular causes.
These hazards include chemicals (carbon mon-
oxide, fine particulate matter, and other cardiac
toxins) and thermal and emotional stress. More-
over, although there has been improvement over
time in respiratory protection during active fire
suppression, such protection may be abandoned
during overhaul (the period immediately after fire
suppression), when exposure to fine particulate
matter (which has been shown to increase the
risk of a sudden myocardial infarction) and other
toxic chemicals may be particularly high.10 Fire-
fighters enter the workforce particularly healthy,
but they do not necessarily maintain that attribute
over time. There is ample evidence that firefght-
ers are not immune to the hazards of overeating
and inadequate regular exercise. For a variety of
reasons, including not only the nature of their
work but also disability plans and presumptive
legislation about work-related health conditions,
career firefighters rarely serve as active firefight-
ers after 50 years of age. Volunteer firefighters,
in contrast, often serve with fewer entry and on-
going fitness requirements, but they serve until
an older age, when most cardiac events occur.
In 2005, of 115 deaths that occurred during on-
duty activities, 81 (70%) occurred among volun-
teer firefighters.11

The implications of this study for firefighters
are clear. Modifiable risk factors, whether or not
they are related to occupation, should be aggres-
sively addressed. We concur with the recommend-
dations of the National Institute for Occupa-
tional Safety and Health arising from the Fire Fighter
Fatality Investigation and Prevention Programs.
First, fire departments should provide mandatory
preplacement and annual medical examinations for all firefighters. These evaluations should include medical clearance for firefighters to wear self-contained breathing apparatuses. Second, wellness and fitness programs should be implemented to reduce risk factors for cardiovascular disease, and third, all firefighters should have annual physical performance evaluations. For firefighters as well as other workers who may face some of these risk factors for cardiac events, decreasing or eliminating occupational risk factors other than heavy exertion (e.g., chemicals, stress, and shift work) is likely to be of benefit. For all workers, whether or not they have physically demanding jobs, the evidence is clear, and this study provides further support for the idea that virtually all sudden deaths from cardiac causes are secondary to underlying coronary disease. Thus, although at least moderate exercise may mitigate the trigger effects of extreme exertion, minimizing the overall risk involves the usual menu of primary and secondary prevention measures. These measures include promoting healthy behaviors (such as a heart-healthy diet, no tobacco or excessive alcohol, and regular exercise) and modifying conditions (such as hypertension, diabetes, and obesity) that pose additional risks.

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An interview with Dr. Rosenstock can be heard at www.nejm.org.

Modern Genetics, Ancient Defenses, and Potential Therapies
Peter K. Gregersen, M.D.

Autoimmunity is the reflection of a basic problem confronting all living organisms — how to defend against foreign invasion while maintaining control of the defending forces. The B-cell and T-cell branches of the immune system can exhibit remarkable specificity for invading microorganisms, can adapt to changing threats, and can provide for long-term immunologic memory. At the same time, autoreactivity of B cells and T cells is present in all normal persons, and a complex set of regulatory mechanisms is required to prevent overt destruction of tissue through autoimmunity.

Our current understanding of autoimmunity rests on our knowledge of the immune system. Over the past 50 years, scientists have concentrated on the adaptive immune system, with a major focus on the diversity and specificity of autoantibodies and the ways in which T cells are regulated. Recently, however, high-throughput genetic and genomic studies have begun to focus attention on the innate immune mechanisms in autoimmunity. The report by Jin et al. in this issue of the Journal is one such study.

The innate immune system is a phylogenetical-