Health effects of vibrations due to trains

Irene van Kamp[1], Elise van Kempen[1], Harm van Wijnen[1], Edwin Verheijen[2] ,Tifanny Istamto[1], Jose Ferreira[1], Oscar Breugelmans[1], Liesbet Dirven[1], Arnold Koopman[3]

[1] National Institute for Public Health and the Environment, Bilthoven, The Netherlands
[2]dBvision, Utrecht Netherlands
[3]Level Acoustics, Eindhoven, The Netherlands

Summary

In the Netherlands circa 845.000 residential addresses, with some 1.347.400 residents of 16 years and older, are located within 300 meter distance to a railroad track. About twenty percent of these residents experience severe annoyance from vibrations caused by trains. They complain about feelings of irritation, anger and discomfort. At night this annoyance can manifest itself in severe sleep disturbance. By far the largest part of annoyance and sleep disturbance is reported in relation to vibrations due to cargo-trains. Some 28% people live at addresses along the railroad where vibration can be perceived, but lie below the limit value of 3.2 mm per second Vmax. For some 2% this limit value is exceeded, a level considered as extremely high. A large part of severe annoyance and sleep-disturbance is found below this limit value. Because it concerns a large number of residents, much health gain can be achieved here. It is therefore important that policy also aims at levels of vibration below the maximum threshold. Factors which amplify the annoyance on top of the vibration strength are fear of damage to the home, expectations that the level of vibration will increase in the future and attitudes towards current development. The health effects of vibration due to trains have rarely been studied among residents. In order to gain more insight in the type and size of these effects and in whom these do occur, a questionnaire survey was held among 4927 people living within 300 meters from a railroad track in the Netherlands. This paper reports on this study with a focus on annoyance, sleep and wellbeing at the outcome side.

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1. Introduction

In reaction to parliamental questions the Dutch Ministry of infrastructure and the Environment is preparing a decision regarding further guidelines for vibrations from rail traffic and an enforcement tool for vibrations along the railroad track. In order to define the content for such guidelines a thorough health impact assessment was seen as necessary. In a recently published literature review [1]it was concluded that a knowledge base is lacking to derive effective norms and guidelines for vibration; research in the field is scarce into the health effects of vibration due to trains. To bridge this gap this study was aimed at investigating the severity of the health effects by means of a survey among residents living in the vicinity of the rail road track. Based on the data that were thus gathered an estimate was made of the number of people living within2300 meter from a track experiencing serious annoyance, sleep disturbance or other health effects.
Based on previous studies it was decided to place the threshold at 300 meter, in which 250-300 can be considered as control area. The survey
In this way provided new information on the extent of the exposure, exposure effect relations and potential other determinants as the building blocks for regulation. The findings of this study can be used for economic and health related tradeoffs once an overview of measures and their costs are available.
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1.1 Problem

The study is based on the following main questions:
1. What is the extent of (i) sever annoyance due to vibrations of trains (ii) severe sleep disturbance (iii) low general health and (iv) self-reported medication use in the Dutch general population of 16 years and older residing within 300 meter from the railroad.
2. Which exposure effect relations can be derived fo sever annoyance, severe sleep disturbance, general health and medication use. Exposure is hereby expressed in distance, RMS and Vmax. RMS is a vibration measure over longer periods, while Vmax refers to the highest effective vibration strength.
3. What is the influence of physical, contextual and personal factors on the under question 1 mentioned effects.

4. How can the findings form 1, 2 and 3 be used for an d effectiveness test and which additional building blocks are needed or this?

2. Method

Bu means of a questionnaire information was gathered about annoyance, sleep disturbance end other perception and health aspects and the determinants of those. Participants were people of 16 year and older residing within 300 meter form the railroad in the Netherlands. They were recruited by sending an invitation to `16.000 addresses selected based on distance, and building year. In addition other situational factors were accounted for such as train intensities. In order to determine to what extent participants differed from non-participants a non response study was performed among an a-select sample of all non-responders. The information gathered with a questionnaire were completed with modelled vibration estimates and noise levels and information from different registries about situational and contextual factors such as the number and types of trains, soil, speed, building year of the dwellings.

2.1 Response

In total 5927 persons (32%) completed a questionnaire. Comparison between responders and non-responders showed some potential selection bias: people who were severely annoyed by vibration of trains participated more often. This leads to somewhat diminished representatively and accompanying distortion of the results. When applying the annoyance findings this potential overestimation has to be taken into account. On the other hand we also observe potential underestimation: the distortion can go two ways. Because of a low response to the non response study (29%) it is not possible to quantify the effect of selective non-response in terms of weighing.

1.3 Exposure

For practical reasons in this study the vibration strength was modelled rather than measured, using the so called. Standard Calculation method for vibrations (SRM-T) [2], which was developed several years ago in the Netherlands. In the Netherlands circa 845.000 residential addresses were lying within 300 from the railroad. At 40% of these addresses the maximal vibration lies above the sensibility threshold of 0,1. Only 1 % lies above the threshold of 3.2 which is the maximum guideline value in the Netherlands as

described in the so called SBR guidelines both in existing as new situations. In view of the reliability of the estimates it has to be taken into account that we worked with generic model parameters. At the local level the situation can deviate. At the moment this is the best model available, but the risk of exposure misclassification can not be excluded. For the evaluation of the exposure in the Netherlands this does not necessarily pose a problem because the levels are averaged over a large number of addresses.

3. Results

Based on the survey the percentage of people of 16 years and older severely annoyed by vibration was estimated to be 20%. By far the highest percentage is related to freight trains .
The percentage severely annoyed is estimated to be 16% in relation to freight trains, and 4% by passenger trains. In the study area the self reported health as measured by the general health question of the SF36 is somewhat better than the national figures form the Bureau for Statistics (81% versus 76%) [3]. Only 3,5% experiences their health as bad. These figures are probably related to the demographic characteristics of the participants. Self reported use of medication is somewhat higher than one would expect based on national reference in particular medication for cardiovascular disease and tranquilizers. Anti-depressives ad asthma and CARA medication score lower. For these differences we do not have a clear explanation.

3.1 Exposure effect relations

Dose effect relations could be derived for severe annoyance and sleep disturbance and the exposure to vibrations expressed in RMS and Vmax and distance. [see also 4]

Figure.1: RMS and percentage severely annoyed (total and per type of train and 95% confidence intervals.

No direct associations were found for general health and medication use. Due to the high association between Vmax and RMS (r >0,70) it is hard to make a distinction between these effects of these measures on annoyance and sleep disturbance.
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3.2 The role of other factors

Above vibration strength the ratio between passenger and freight-trains, day and night exposure and the type of dwelling along the railroad play an important role. Moreover the attitude towards rail traffic, fear for damage to the dwelling and the visual experience of moving objects (rattle) as well as expectations about future exposures affect the percentage of severely annoyed and sleep disturbed as well as acceptance of vibrations. The findings are comparable with those from the Salford study and cargo-vibe study [5][6] The observed association between vibrations and these effects are independent of the noise levels and accompanying annoyance and disturbances.

3.3 Compensation

An independent committee which monitors the situation in the area on a regular basis which makes the findings public, intervention in and at the dwelling, and a fund for people living near the railroad for eventual damage to the house are brought forward as the most favorite measures (70%-77%).
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4. Conclusions and implications for policy

1. The results of this study indicate unfavorable effects of the exposure to vibration form train traffic on annoyance and sleep disturbance. g.
2. Most people living within 300 meters from the rail road are exposed to levels below the sensibility threshold of 0.1 mm/s . Around 528.000 persons are confronted with exposure levels between 0.1 – 3.2 mm/s (Vmax), the range at which vibration could cause relatively high disturbance.
A relatively small proportion (some 11.000 persons are exposed to levels above 3.2 mm/s (Vmax).
3. The proportion of people living within 300 meter for the railroad experiencing severe annoyance is relatively high with some 6.000 persons (2%) at levels above 3.2 mm/s (Vmax); 22.000 persons (8%) ate levels between 1.6 - 3,2 mm/s (Vmax); and some 128.000 severely

annoyed (49%) ate levels between 0.1 to 1.6 mm/s, while 107.000 severely annoyed live below the (41%)
Sensibility threshold of 0.1 mm/s (Vmax). For policy this means that in order to reduce the negative effects and health effects it is not sufficient to maintain the so called Bts-threshold value of 3.2 mm/s. Also and in particular the group between 0,1-1.6 mm/s much health gain could be sorted .
4. In specific the freight trains are experienced as annoying (23%) and sleep disturbing (16%) and interventions should be aimed at freight transport
5. The association between vibrations and these effects could not be explained by noise
6. No preference for an exposure measure could be given based on the findings. The three measures are highly correlated and the strength of the associations with effects if comparable. They thus offer comparable protection levels in steady state situations. With a strong increase of rail frequencies it is expected between RMS and Vmax. RMS is in contrast with Vmax also dependent of the number of trains passages causing vibration. Follow up research is necessary to map the effects and quantify these.
7. Interventions should be aimed primarily at the source but also contextual and personal factors should be addressed such as attitude, acceptation, fear for damage and expected train intensities in the future. The preference for compensation measures as indicated by the residents are important starting points for this..
8. The derived exposure effect relations could be applied to calculate the effectiveness and efficacy of measures/interventions and to compare outcomes at a national level. Also at a local level scenarios could be compared but quantification is much more problematic at that level because situational factors are influencing the annoyance experienced. It concerns measure directed at the source and at parameters which indirectly affect RMS and VMax.
The exposure effect relations could be used in the future to estimate the effect of planned changes in the number of trains (more, less, remain the same) using after measures at different moments in time.
9. And finally: de results from this study are meant to draw conclusions at population level only: No inferences can be made about individual dwellings or tracks.

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References

[1] Kempen EEMM van, Baumann RA, Wijnen HJ van, Kamp I van, Gezondheidseffecten van trillingen door treinen. Een review 2013, RIVM: Bilthoven.

[2] Steenbergen RDJM, Lentzen SSK, Koopman A, Betrouwbare trillingsmaatregel ontwikkeling Standaard RekenMethode voor Trillingen (SRM-T). 2009, TNO: Delft.

[3] Centraal Bureau voor de Statistiek. CBS Statline. 2014.

[4] Janssen SA, Vos H, Koopman A, Deliverable D1.2 - Exposure-response relationships and factors influencing these relationships. 2013, CargoVibes.

[5] Peris E, Woodcock J, Sica G, Moorhouse AT, Waddington DC, Annoyance due to railway vibration at different times of the day. Journal of the Acoustical Society of America, Express Letters, 2012. 131(2): p. 191- 196.

[6] Peris E, Woodcock J, Sica G, Sharp C, Moorhouse AT, Waddington DC, Effect of situational, attitudinal and demographic factors on railway vibration annoyance in residential areas. Journal of the Acoustical Society of America, 2014. 135(1): p. 194-204.